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ABSTRACT

Twenty-seven lesson plans for a fourth-year electrical apprentice technical training program are presented in this instructor's manual. Also included are student worksheets and information sheets for each lesson, and copies of unit tests. (Answers to the worksheets and tests are provided.) The lesson plans are generally organized into four steps: introducing the lesson, presenting the lesson (e.g., demonstration), student application (use of worksheets), and checking and follow-up (checking answers to worksheets). Some of the lesson topics are cable trays, cellular metal floor raceways, switchboards and panelboards, radio and television equipment, troubleshooting control circuits, basic theory of electronics, and effective foremanship. (Student worksheets and information sheets for this training program are also available separately--CE 018 360. Other related documents include a basic mathematics review, jobsite supervisor's manual, and instructor's manuals and worksheets for the other three years of the program--see note.) (JH)

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ED160884

INSTRUCTOR'S MANUAL
FOR
ELECTRICAL APPRENTICE
TECHNICAL TRAINING

SERIES NO. D
(Fourth Year)

Revised to meet 1978 Electrical Code

PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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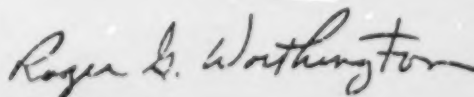
CE 018 359

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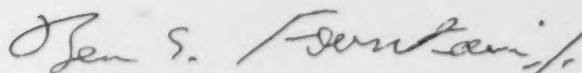
FOREWORD

The apprenticeship programs offered in North Carolina are important phases of the total educational program for industry in the state. The program of education for modern apprenticeship includes two distinct phases. The first phase is "on-the-job training." The student is employed by a firm in which duties are specifically assigned to enhance ones learning in the field of study. These experiences are planned and supervised so that the individuals will progress through the apprenticeship phase to that of the journeyman. The second phase of the program of education is termed "related instruction." In this phase the apprentice is provided the technical and theoretical foundation subjects that help one to learn the trade thoroughly and accurately. This portion is usually taught through evening school, but in some cases may be done through correspondence courses.

The North Carolina Department of Community Colleges, through the Program Development Section, has the responsibility for developing and making available the instructional materials that provide the learner with a sound educational program which is effective and appropriate to the method in which the materials are being utilized. The department has available these materials for the students, as well as support material for the instructor who teaches or who acts as counselor in conducting the related classes.



Roger G. Worthington, Director
Program Development



Ben E. Fountain, Jr., State President
Department of Community Colleges

PREFACE

The Program Development Section of the Department of Community Colleges has the responsibility for making available the related instructional materials required for use in occupational programs offered by the various institutions. This responsibility is accomplished by working with advisory committees and consultants representing each of the occupations in determining the needs and in developing the materials required to meet these needs.

These information sheets and worksheets have been prepared to provide specific assignments for studying related topics necessary in the training of electrical apprentices. An effort was made to develop the schedule to follow as the apprentice progresses with training. It will also enable the apprentice to know what skills and knowledges will be required. The objective of this program is to aid the instructor and employer in providing experiences necessary to develop not only a competent worker in the electrical field, but also, a well-rounded citizen.

This workbook includes assignment sheets and information sheets for the electrical apprentice to use in searching out related information. The worksheets contain problems to solve, questions to answer diagrams to draw, and blueprints to consult. The apprentice should study the references (assigned by the instructor) before attempting to answer the questions or solve the problems.

In actual use of these lessons, instructors should feel free to modify their application of the material to conform with local needs. For example, there may be certain sections of the Code to teach because the apprentices are working with special installations. Thus, the instructor should lead a discussion on materials that applies to these situations. In other classes, the instructor may need to spend more time with the students on topics dealing with mathematics than with blueprint reading. In any event, the minimum class time for related material is 144 hours per year. It is sincerely hoped that the assignment sheets are used correctly so that apprentices can gain maximum benefits from their related studies.

ELECTRICAL APPRENTICESHIP TECHNICAL TRAINING

ACKNOWLEDGMENTS

Questions and problems for the Lesson Topics were prepared in July, 1964 by:

W.F. Humbert, III, Electrical Engineer
Winston-Salem, North Carolina

The Instructor's Manuals, Information and Orientation Sheets were developed by:

Howard E. Hedinger, Educational Consultant
Department of Community Colleges
Raleigh, North Carolina

The manual was revised in 1967, 1971, and 1975.

REVISION COMMITTEE 1978

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*Note #2: Article Numbers Listed

*Note #3: Division and Section Numbers Listed

*Note #4: Chapter and Page Numbers Listed

*Note #5: Basic Math References in left column are 2nd Edition;
Basic Math Ref. in last column are 3rd Edition, 1972.

(Continued)
 ASSIGNMENT
 NAME (TITLE)

LESSON
 NO.

BASIC
 MATH

BASIC
 ELECTRICITY

1975
 N.E.
 CODE

AMERICAN
 ELECTRICIAN'S
 HANDBOOK

ELECTRIC
 MOTOR CONTROL
 FUNDAMENTALS

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(Continued) ASSIGNMENT NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	1975 N.E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	ELECTRIC MOTOR CONTROL FUNDAMENTALS	OTHER MATERIALS
Job Management	D-26						
Effective Foremanship	D-27						

D-1

ELECTRICAL APPRENTICE TECHNICAL TRAINING
(GUIDELINES)

TO THE INSTRUCTOR:

- It is suggested that the instructor use an Orientation Sheet to help him become acquainted with the new apprentices. Name, address, birth-place, education, employers, and type of work, sponsoring employer, home situation (marital status and number of children), hobbies, likes and dislikes, etc., should be included.
- The Instructor's Manual and the Assignment Sheets or Worksheets have been revised to update the materials. Lessons are arranged in topics to reflect electrical installation in compliance to the N.E. Code.
- The brief Lesson Plans should act as a guide in conducting classes and in organizing the program. It is recommended that you write out your own plans, using illustrations that are familiar and timely.
- The Information Sheets and Worksheets are designed to help the apprentice master the related technical materials found in textbooks and references. The answer sheets are included in the Instructor's Manual.
- The fourth year (Series D) of the course in Technical Training for Electrical Apprentices is designed, as was the first three years, to make it easier for the instructor. The lesson outlines should help the instructor lead his classes gradually into the more complex phases of the study of Electrical Installation as required by the National Electrical Code.
- It should be noted by the instructor that:
 1. Topics on basic mathematical principles were reviewed and other applied topics were introduced during the first year (Series A). The second, third, and fourth year series contain no topics specifically on mathematical subjects. Yet the instructor will realize that additional practice in handling equations will be necessary for most apprentices by the time they begin to study alternating current. It will be essential for the instructor to pay special attention to these mathematical tools in order to be sure that the electrical theory will be completely understandable to the apprentices.

In the event that some of the apprentices are weak in mathematics, the instructor should make additional assignments in math problems using the Learning Resource facilities at the institution or give special individual help.

2. In this course, the topics on the National Electrical Code will be studied in terms of wiring methods. It is hoped that by studying the Code along with other subjects each year will help create interest and will be better applied to job situations.
3. There is a suggested list of audiovisual aids; however, the instructor should use any other aids available, but be sure to order them in ample time. It is hoped that the instructors will not have too much difficulty obtaining particular aids at the time they need them.

NOTE: A new list of audiovisual aids is being prepared.

- ° In the event the instructor uses individualized self-pacing methods where the students work at their own pace, he may need more programmed materials. Consult the Learning Lab for help in such case.
- ° Assignments and page references have been placed on a sheet following the Table of Contents. This sheet can be revised easier than all the lesson sheets when textbooks are changed. It is suggested that the references be written on the chalkboard for each assignment.
- ° Each apprentice or student should have a large three-ring notebook to keep the lesson sheets, assignments, and notes.
- ° Answer sheets for both the Worksheets and the Tests have been placed in the Instructor's Manual for your use.
- ° Corrections for the Worksheets will be attached or listed in the Instructor's Manual. Please call attention to errors in printing when you make the assignment.
- ° THE FOUR-STEP OUTLINE

Each lesson plan is outlined into the "four-step" method of instruction and should assist you in presenting the lessons. In group instruction, it is recommended that the class period include the following:

STEP I - INTRODUCING THE LESSON:

Call attention to interesting facts concerning the subject.

STEP II - PRESENTING THE LESSON:

Demonstrate the use of necessary tools, materials, problems, and experiments. A well-presented lesson will require the student to do a minimum of reading in the assigned texts. Note: When adequate equipment is provided, each student can perform the experiments individually. Show films or slides related to the subject. Discuss problems encountered on the job.

STEP III - APPLICATION

Make use of the Assignment Sheets prepared for each lesson. The assignments serve not only as a valuable aid to the learner, but also indicate to the instructor how well the lesson was taught.

STEP IV - CHECKING AND FOLLOW-UP:

Check the worksheets with the aid of answer sheets. This can be done quickly by the instructor or by exchange of papers in class. Return the papers to the students to correct mistakes and give individual help to those who need it. Call attention to common errors and discuss the problems or questions which were incorrect.

NOTE: Make assignments for the next week.

TESTING PROCEDURES:

1. Short tests can be given each week on the lesson or the previous assignment.
2. A thorough test should be given shortly after completing a unit or group of lessons. This test should cover six weeks work or less.
3. A good comprehensive test administered at the end of the course will act as a gauge of progress for the year. Some questions, with the use of charts, tables, and the National Electrical Code, can be of the "open book" type.
4. All tests should be checked in detail, reviewed in class, and returned to you. Tests should be retained by you and the committee as a part of the student's record.

- Please note that the assignment references for textbooks list the page numbers.

The National Electrical Code references are "Articles."

The American Electrician's Handbook lists the Division and Section; these are not the page numbers.

- TEXTBOOKS:

NOTE: Book stores at the institutions can order the textbooks and receive the school discount.

The National Electrical Code - latest edition.

American Electrician's Handbook by Croft, Carr, and Watt;
9th edition, 1970.

Basic Electricity by Van Valkenburgh, Nooger, and Neville;
1st edition, 1954, Volumes 1-5.

Basic Mathematics for Electricity and Electronics by Singer.
3rd edition, 1972.

AC Motor Control Fundamentals by McIntyre, 2nd edition. (Used
for 3rd and 4th year assignments only.)

- INSTRUCTIONAL MATERIALS:

The necessary materials should be ordered from the Department of
Community Colleges, Program Development, Raleigh, N.C. 27602

1. Instructor's Manual - Fourth year - Series D
2. Student Information Sheets and Worksheets-Third Year, Series C
3. Mathematics Pretest
4. Basic Mathematics Review
5. MAT 1111 - Slide Rule
6. Supplementary Materials List for Electrical Apprentice Technical Training
7. Tests (Series D) Copy of tests without answers is included in Instructor's Manual; please have your own student tests printed.

* 3rd Edition, 1972, is available.

CABLE TRAYS

DESIRED RESULTS:

1. To study the requirements of the Code concerning the support of the conductor assemblies.
2. To become acquainted with approved materials used for the trays.
3. To learn the approved and non-approved areas for using and installing cable trays.

INTRODUCTION AND PRESENTING THE LESSON:

It is the intent of Article 318 to make sure that the trays have mechanical strength, good finish, and are adequately protected against corrosion.

The cable trays, ventilated or non-ventilated, shall be made of non-combustible materials. They may be used for the support of the conductor assemblies described in the Code.

DISCUSSION QUESTIONS:

1. Discuss the construction of cable trays.
2. Review the uses of cable trays.
3. How should cable trays be installed?
4. What is said about extension of the trays through walls?
5. How shall the cable trays be grounded?
6. Discuss wiring methods:
 - a. How many layers of cable are allowed in one cable tray.
 - b. How many layers of Type MC cable can be installed in a tray.
 - c. What type of tray can be used in industrial, commercial, or other occupancies?
 - d. How is the current-carrying capacity for power and control cables determined?

APPLICATION:

Have the students complete the assignment questions for this lesson.

CHECKING AND FOLLOW-UP:

Check the papers and return them to the students for correction and placing in their workbooks.

NAME _____

LESSON D-1

DATE _____

WORKSHEET

CABLE TRAYS

REFERENCE: National Electrical Code - Article 318

1. Trays shall have side rails or equivalent structural members.
True/False TRUE Code Reference 318-3 (4)

2. Cable Trays shall be installed as a complete SUPPORT system.

3. Each run of cable trays shall be complete before the INSTALLATION of cables.

4. The minimum vertical clearance between tiers shall be 12 inches.

5. All parts of the cable trays shall be bonded together and GROUNDED.

6. List three types of cables that may be used in cable trays.

- (a) MI CABLE
- (b) METAL-CLAD CABLE
- (c) NON-METALLIC SHIELDED AND SHEATHED CABLE

- (d) POWER AND CONTROL TRAY CABLE
- (e) MULTI-CONDUCTOR UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE
- (f) MULTI-CONDUCTOR SERVICE ENTRANCE CABLE

Alternate Answers: (d-f)

7. A cable tray system may be used as a grounded circuit conductor.
True/False TRUE Code Reference 318-6 (B) (2)

8. Where 600 volt and 5 KV cables are installed in the same cable tray, solid NON - COMBUSTIBLE partitions shall be provided to SEPARATE the types of CABLES. 318-5 (F) EXCEPTION 1

9. Trays shall not extend through FIRE walls.

10. Trays may be used for exposed work in HAZARDOUS or NON - HAZARDOUS locations.

11. List three areas approved for using cable trays:

- (a) NON-HAZARDOUS
- (b) HAZARDOUS - IF APPROVED
- (c) AS MECHANICAL SUPPORT FOR FACTORY-ASSEMBLED CABLES

12. List three areas not approved for using cable trays:
- (a) HOISTWAYS
 - (b) AREAS SUBJECT TO SEVERE PHYSICAL DAMAGE
 - (c) AREAS WITH READILY COMBUSTIBLE CONTENTS
13. Are single conductor cables allowed to be installed in cable trays?
YES. Code Reference 318-2(B) OR 318-7 (D)
14. If the answer to question #13 is Yes, Give the minimum size conductor permitted. 250 MCM.
15. The minimum horizontal distance between cable trays shall be ADEQUATE FOR INSTALLING AND MAINTAINING CABLES.
16. Trays shall be CONTINUOUS and MECHANICALLY connected to the enclosure in which cables terminate.

NAME _____

LESSON D-2

DATE _____

WORKSHEET

NONMETALLIC EXTENSIONS

REFERENCE: National Electrical Code - Article 342.

1. Nonmetallic extensions shall be made from a 15 or 20 ampere branch circuit.
2. Nonmetallic extensions shall be mounted a minimum of two inches above the FLOOR.
3. Nonmetallic extensions may be installed in a residence or OFFICE.
4. An extension shall be attached only to woodwork or PLASTER.
5. Nonmetallic extensions may be installed in an unfinished basement. True/False FALSE Code Reference 342-4 (B)
6. Nonmetallic extensions shall not be installed where subject to CORROSIVE vapors.
7. Each run of nonmetallic extensions shall terminate in a fitting which covers the END of the assembly.
8. Nonmetallic extensions may be run exposed in a DRY location.
9. Nonmetallic extensions may extend outside the room in which it originates. True/False FALSE Code Reference 342-4(E)
10. Fastenings shall be located a MAXIMUM of eight inches on centers.
11. Splices and TAPS shall not be made in nonmetallic extensions except in approved fittings.
12. Receptacle type tap connector shall be of the LOCKING type.
13. Fastenings shall be located a maximum of 8 inches on centers.
14. The end of the extension shall terminate in a FITTING.

NONMETALLIC EXTENSIONS

DESIRED RESULTS:

To become acquainted with the Code requirements concerning non-metallic extensions.

MATERIALS:

Samples of nonmetallic extension wiring.

INTRODUCTION:

Nonmetallic surface extensions are two-wire assemblies designed to be fastened to the wall or baseboard. This will supply additional convenience outlets from an existing convenience outlet. The existing outlet has to be supplied from some other approved method of wiring. Examples of two types of nonmetallic surface extensions will be given here.

1. The electrotrim consists of an assembly of two No. 14 rubber-covered wires without braid sewed into a specially treated fabric. Tacks or small nails may be used in the under layer of the fabric between the wires for securing the assembly in place. The top layer of fabric forms a flap and covers the heads of the tacks. A plug is fastened to the end of the strip and plugged into the existing outlets.
2. Adhere is another type of extension wiring consisting of a high grade rubber molding in which two No. 14 bare stranded conductors have been placed. A special cement is supplied by the manufacturer by means of which the assembly can be firmly secured to the surface of almost any material used for interior finish. Using Adhere, the existing outlet is removed and remounted on a special 1/2 inch box extension into which the strips run.

Nonmetallic surface extensions can be used only in dry non-corrosive vapor locations in residences and offices for not more than 150 volts. They must not run closer than 2 inches from the floor and must not run outside the room in which they originate. They must be fastened at least every 8 inches, except that the first fastening from the attachment plug may be 12 inches from the plug. This type of wiring materials is several times as expensive as armored cable or nonmetallic sheathed cable.

DISCUSSION QUESTIONS:

1. Describe nonmetallic extensions.
2. Where can nonmetallic extensions be used?
3. Where is the use of nonmetallic extensions prohibited?
4. Are splices and taps permitted when using nonmetallic extensions?
5. What are the requirements to use when installing nonmetallic extensions?

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

UNDERPLASTER EXTENSIONS

DESIRED RESULTS:

To study the Code regulations concerning underplaster extensions.

INTRODUCTION:

Underplaster extensions are wiring systems laid in a channel cut in the plaster surface of a wall, down to the face of masonry or other wall material. Rigid or flexible metal conduit, armored cable, electrical metallic tubing, or metal raceways approved for the purpose are laid in the channel and secured to the surface of the wall or ceiling structure. Provision for outlets is made by inserting shallow outlet boxes in the run of conduit, cable, tubing, or raceway. After the system has been secured in the channel, it is plastered over flush with the wall or ceiling surface.

The National Electrical Code allows such changes to be made in buildings of fire resistive construction.

DISCUSSION QUESTIONS:

1. When can an underplaster extension be installed?
2. What materials are used for underplaster extensions?
3. List the boxes and fittings specified in Article 370 to be used with underplaster extensions.
4. Discuss the installation of an underplaster extension.

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-3

DATE _____

WORKSHEET

UNDERPLASTER EXTENSIONS

REFERENCE: National Electrical Code - Article 344.

1. An underplaster extension may be used only for extending an existing BRANCH circuit.
2. An underplaster extension may be installed in a FIRE - RESISTIVE constructed building only.
3. NM cable may be used for underplaster extension. True/False FALSE
Code Reference 344-2
4. List five types of raceways approved for underplaster extensions:
 - (a) RIGID CONDUIT
 - (b) FLEXIBLE CONDUIT
 - (c) AC METAL CLAD CABLE
 - (d) EMT
 - (e) MI CABLE
5. Underplaster extensions shall not extend beyond the FLOOR where it originates unless it is installed in RIGID metal CONDUIT, AC metal clad cable, or M I cable.
6. Underplaster extensions shall be mounted on the face of MASONRY walls.
7. Underplaster extensions shall be buried in PLASTER finish of ceiling or WALLS.

SURFACE METAL RACEWAYS

DESIRED RESULTS:

To become acquainted with the use, installation and construction specifications of surface metal raceways.

INTRODUCTION:

In surface metal-raceway wiring, the wires are supported in a thin sheet-steel casing. The raceway is installed exposed, being mounted on dry walls or ceilings. The sheet-steel casing, called metal raceway or metal molding, is made with a flattened-oval or rectangular cross section. Most types of molding are made in two parts, a trough or base which is fastened to the wall or ceiling and a capping which is snapped on the base. One type of surface metal raceway is manufactured with the capping crimped on the base at the factory. With this type, the wires must be pulled through the raceway from outlet to outlet as in the conduit-wiring method. Provisions for outlets or switches are made by means of special fittings inserted in the runs of molding.

DISCUSSION QUESTIONS:

1. List places where surface metal raceway should not be used.
2. Discuss the size and number of conductors to be installed in any raceway.
3. How should surface metal raceways be extended through walls and floors?
4. Discuss the use of combination raceways.
5. What are the general construction specifications for surface metal raceways and the fittings?

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in their workbooks.

NAME _____

LESSON D-4

DATE _____

WORKSHEET

SURFACE METAL RACEWAYS

REFERENCE: National Electrical Code - Article 352.

1. Installations of surface metal raceway shall comply with the applicable provisions of Article 300.
2. The conductors, including splices and taps, shall not fill the raceway to more than 75 percent of its area at that point.
3. All splices and taps shall be made by APPROVED methods.
4. Multi-outlet assemblies may be extended through dry walls.
True/False TRUE Code Reference 352-5
5. The maximum voltage permitted in a surface metal raceway is 300 volts. Can it be normally higher YES (ART 352-1)
6. No conductor LARGER than that for which the raceway is designed shall be installed in surface metal raceway.
7. Surface metal raceway may be installed in hazardous locations.
True/False FALSE Code Reference 352-1
8. Surface metal raceway shall be installed in DRY locations only.
9. Surface metal raceways may extend through WALLS and FLOORS.
10. Raceway shall be CONTINUOUS from outlet to outlet.
11. Name the tool used to cut surface metal raceways. HACKSAW
12. The minimum support for surface metal raceway is 4 feet.
13. In general surface metal raceway is 10 feet long.
14. Combination raceways shall have SEPARATE compartments for signal, lighting, and power circuits.
15. Screw or bolt-heads shall be installed FLUSH with the interior surface of the raceway they support.
16. Are non metallic surface raceways permitted? YES
Code Reference 352-21

MULTIOUTLET ASSEMBLY

DESIRED RESULTS:

To understand the requirements of the Code concerning the installations of multioutlet assembly.

INTRODUCTION:

Installations of multioutlet assembly shall comply with applicable provisions of Article 300. Refer to Article 100 for definitions. Stress that multioutlet assembly may be installed in dry locations.

DISCUSSION QUESTIONS:

1. Review the definition of multioutlet assembly.
2. Discuss the various uses of multioutlet assembly.
3. Why is the multioutlet assembly not installed in any hazardous location?

APPLICATION:

Have the students complete the questions on the worksheet.

CHECKING AND FOLLOW-UP:

Check the answers, discuss the errors, and place the sheets in the notebooks.

NAME _____

LESSON D-5

DATE _____

WORKSHEET

MULTIOUTLET ASSEMBLY

REFERENCE: National Electrical Code - Article 353.

1. Metal multioutlet assembly may be extended through DRY partitions.
2. Assembly may be installed in (A) DRY location(s).
(a) dry (b) wet (c) both
3. Nonmetallic multioutlet assembly may be recessed in the (A) BASEBOARD.
(a) baseboard (b) ceiling (c) both
4. What type of assembly may be installed where subject to severe physical damage? APPROVED FOR PURPOSE
5. Assembly may be installed in any hazardous location. True/False
FALSE Code Reference 353-2
6. Assembly is a raceway designed to hold CONDUCTORS and RECEPTACLES.
7. Assembly may be FIELD or FACTORY assembled.
8. Assembly shall not be installed in hazardous locations such as CORROSIVE vapors or in HOISTWAYS.
9. Assembly may be installed from ROOM to ROOM provided the partitions are dry and contain no outlets.
10. Receptacles in a multioutlet assembly shall be THREE-wire, GROUNDING type.

UNDERFLOOR RACEWAYS

DESIRED RESULTS:

To study the Code requirements concerning the use and installation of underfloor raceways.

INTRODUCTION:

Underfloor raceway systems are used principally in office buildings for the installation of the wiring for telephone and signal systems, and for convenience outlets for electrical office machines. They provide a flexible system for the location of outlets to accommodate the rearrangement of furniture and partitions. The National Electrical Code allows their use only in buildings of fireproof construction when embedded in the concrete or in concrete fill of the floors. Their installation is allowed only in dry locations which are free from corrosive or hazardous conditions. No wires larger than the maximum size approved for the particular raceway should be installed. The voltage of the system must not exceed 600 volts. The ducts for this raceway system are made of either fiber or steel.

DISCUSSION QUESTIONS:

1. In general, how are underfloor raceways installed?
2. How are open-bottom type of raceways installed?
3. List two places where underfloor raceways should not be installed.
4. Discuss how raceway coverings should conform to the Code.
5. Discuss the size and number of conductors allowed in a raceway.
6. How should the underfloor raceways be laid?
7. How are the ends of installed raceways designated?
8. Discuss how to install (a) junction boxes, (b) inserts, and (c) wall outlets.

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-6

DATE _____

WORKSHEET

UNDERFLOOR RACEWAYS

REFERENCE: National Electrical Code - Article 354.

1. Underfloor raceway shall not be installed where subject to CORROSIVE vapors.
2. Dead ends of raceways shall be (A) CLOSED.
(a) closed (b) left open for future use
3. The combined cross-sectional area of all conductors shall not exceed (A) 40 percent of the interior area of the raceway except that when raceway contains only type AC or NM sheathed cable.
(a) 40 (b) 50 (c) 60
4. Junction boxes used with metal raceways shall be (A) METAL.
(a) metal (b) plastic (c) wood
5. Inserts set in fiber raceways after the floor is laid shall be SCREWED into the raceway.
6. Raceways spaced less than one inch apart shall be covered with concrete to a depth of 1 1/2 inches.
7. Approved flush raceways with removable covers may be laid FLUSH with the floor surface.
8. No conductor larger than that for which the raceway is DESIGNED shall be installed in underfloor raceways.
9. Markers shall extend through the finish of the FLOOR.
10. Installations of underfloor raceways shall comply with the applicable provisions of Article 300.
11. Splices and taps shall be made only in JUNCTION BOXES.
12. Conductors supplying a discontinued outlet shall be removed from the UNDERFLOOR RACEWAY.
13. Where raceways are run at other than right angles, SPECIAL FITTINGS shall be provided.
14. Describe "Loop Wiring". A CONTINUOUS, UNBROKEN CONDUCTOR
CONNECTING THE INDIVIDUAL OUTLETS.

14. A marker fitting shall be installed at the end of every line of the RACEWAY.
15. Underfloor raceways in office buildings may be used for low voltage POWER, TELEPHONE and SIGNAL systems.
16. The maximum voltage permitted in a raceway is 600 volts.
17. All joints in raceway shall be SEALED.
18. Metal raceways shall be properly GROUNDED.
19. Wires for TELEPHONE or SIGNAL systems shall not be run in the same duct with convenience outlet wires.
20. In junction boxes, separate COMPARTMENTS shall be provided for each system.
21. No SPLICES or taps shall be made at outlet inserts.

CELLULAR METAL FLOOR RACEWAYS

DESIRED RESULTS:

To become acquainted with the use and installation of conductors in cellular metal floor raceways.

INTRODUCTION:

The term cellular metal floor refers to a type of floor construction designed for use in steel-frame buildings. The members supporting the floor between the beams consist of sheet steel rolled into shapes which are combined to form cells. These passageways extend across the building and are of various shapes and sizes, depending upon the structural strength required. These cellular members can be adapted as underfloor raceways with the use of suitable fittings.

DEFINITIONS:

1. A cellular metal floor raceway consists of the hollow spaces of cellular metal floors, together with suitable fittings, which may be approved as enclosures for electrical conductors.
2. A cell is a single, enclosed tubular space in a cellular metal floor member. The axis of the cell will run parallel with the axis of the metal floor member.
3. A header is a transverse raceway for electrical conductors from which they are distributed to the cells.

DISCUSSION QUESTIONS:

1. List conditions when the installation of conductors should not be permitted.
2. Give the limit on size and number of conductors allowed in a metal floor raceway.
3. Where should the electrician make splices and taps?
4. What is the Code rule for discontinued outlets? Markers?
5. How should junction boxes and inserts be installed?
6. Give some general construction specifications for cellular metal floor raceways.

APPLICATION:

Have the students answer the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-7

DATE _____

WORKSHEET

CELLULAR METAL FLOOR RACEWAYS

REFERENCE: National Electrical Code - Article 356.

1. No conductor larger than # 1/0 shall be installed in any cell or header except by special permission.
2. Inserts shall be LEVEL with the floor grade.
3. Inserts shall be SEALED against the entrance of water.
4. Inserts shall be made of METAL material.
5. Inserts shall be ELECTRICALLY continuous with the raceway.
6. Splices and taps shall be made only in header access units or JUNCTION BOXES.
7. Conductors feeding a discontinued outlet shall be REMOVED from the raceway.
8. Markers shall be installed throughout the system for future IDENTIFICATION of electrical cells.
9. In commercial garages, conductors may be installed in raceways feeding ceiling outlets or extensions to AREA BELOW the FLOOR.
10. So called loop wiring is not considered to be a splice or tap in cellular metal floor raceway. True/False TRUE Code Reference 356-6
11. A "header" duct is a transverse raceway for electrical conductors. True/False TRUE Code Reference 356-1
12. Header provides access to predetermined CELLS of a cellular metal floor.
13. Header permits the installation of electrical CONDUCTORS from a distribution center to the cells.
14. Core DRILLS are used to cut hole in center of cell.
15. In general, the cells of a cellular metal floor are on SIX inch centers.

CELLULAR CONCRETE FLOOR RACEWAYS

DESIRED RESULTS:

To become acquainted with the scope, use, and installation of conductors in precast cellular concrete floor raceways.

INTRODUCTION:

The title Precast Cellular Concrete Floor refers to a type of floor construction designed for use in steel frame, concrete frame, and wall bearing construction. The precast reinforced concrete floor members form the structural floor and are supported by beams or bearing walls. These precast floor members have hollow voids which form smooth round cells. The cells are of various sizes depending on the size of floor member used. The cells with the use of suitable fittings can be adapted for underfloor raceways. This floor is fire-resistant and requires no additional fireproofing.

DEFINITIONS:

1. For the purposes of this Article, precast cellular concrete floor raceways shall be defined as the hollow spaces in floors constructed of precast cellular concrete slabs. These contain suitable metal fittings designed to provide access to the floor cells.
2. A cell shall be defined as a single, enclosed tubular space in a floor made of precast cellular concrete slabs. The direction of the cell being parallel to the direction of the floor member.
3. Header ducts shall be defined as transverse metal raceways for electrical conductors. These raceways furnish access to pre-determined cells in the concrete floors. They provide for the installation of electrical conductors from a distribution center to the floor cells.

DISCUSSION QUESTIONS:

1. Give examples where conductors should not be installed in precast cellular concrete floor raceways.
2. How should the header duct be installed?
3. How should the connections to cabinets and other enclosures be made from the header duct?

4. How should junction boxes be installed?
5. How should hidden access points be identified?
6. What material should inserts be made of and how are they installed?
7. What is the size and number of conductors allowed in raceways?
8. Where are splices and taps allowed?
9. What should be done with discontinued outlets?

APPLICATION:

Have the students complete the Assignment questions.

CHECKING AND FOLLOW-UP:

After checking the questions, return them to the students for correction and placing in their workbooks.

NAME _____

LESSON D-8

DATE _____

WORKSHEET

CELLULAR CONCRETE FLOOR RACEWAYS

REFERENCE: National Electrical Code - Article 358.

1. No conductor larger than # 1/0 shall be installed, except by special permission.
2. Splices and taps shall be made only in header access units or JUNCTION BOXES.
3. Conductors supplying DISCONTINUED outlets shall be removed.
4. Connections to cabinets and extensions from cells to outlets shall be made by means of RIGID or FLEXIBLE conduit or approved fittings.
5. Inserts shall be LEVEL with the floor.
6. Inserts shall be SEALED against the entrance of water.
7. Conductors shall not be installed in a raceway in CORROSIVE or HAZARDOUS locations.
8. Conductors shall not be installed in raceway to supply outlets in the area above the FLOOR of a commercial garage.
9. Headers are installed perpendicular to the AXIS of the cells.
10. Headers is a metal raceway providing access to predetermined CELLS in the slab.
11. Installations of conductors in the raceway of cellular metal floor shall comply with the applicable provisions of Article 300.
12. Header duct end joints shall be closed by METALLIC closure fittings.
13. Header duct shall be ELECTRICALLY continuous through the system and shall be ELECTRICALLY bonded to the enclosure of the DISTRIBUTION SYSTEM.
14. Connections between cabinet and header shall be made by means of METALLIC DUCT and APPROVED FITTINGS.

15. Receptacles shall be of the GROUNDING type.
16. A GROUNDING conductor shall connect the receptacle to a positive ground connection on the HEADER duct.
17. Cellular concrete floors are constructed of PRECAST CELLULAR concrete members.

BUSWAYS

DESIRED RESULTS:

To understand the use and installation of busways for an interior wiring system.

INTRODUCTION:

Busway is one of the newer developments in interior wiring systems. It provides a flexible power distribution system for industrial plants and school shops for motors and in some cases, lights. This method provides for the connecting branch motor circuits to the mains readily and economically when machines are rearranged. The system has a wide use in industrial plants where the layout of the machines must be continually changed in order to meet changing manufacturing conditions. The first cost may be somewhat greater than for other methods of wiring, but the savings derived from its flexibility in the relocation of machines without additional wiring expense soon overbalances the additional first cost. With the flexible busway method of wiring there is no ripping out and scrapping of old materials and installing new materials to meet the new layout conditions. Busway may be installed in exposed dry locations for circuits of not more than 600 volts.

Busways consist of bus bars mounted in a sheet metal enclosure or trough. They are made in three main types for voltage up to 600 volts:

- (1) Without plug-in provision
- (2) With plug-in provision at fixed intervals
- (3) With movable trolley contacts

Busways of over 600 volts are also available for use in special applications.

NOTE: If it is possible, visit a busway installation.

DISCUSSION QUESTIONS:

1. List places where busways should not be installed.
2. How should the busways be supported?
3. How are branch circuits made from busways?
4. Discuss overcurrent protection in busways and branch circuits.

APPLICATION:

Have the students answer the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-9

DATE _____

WORKSHEET

BUSWAYS

REFERENCE: National Electrical Code - Article 364.

1. Busway shall be installed only for exposed work. True/False FALSE
2. Busways may be installed as service ENTRANCE conductors.
3. Approved busways may be installed outdoors or in WET or DAMP locations.
4. List three areas in which busways are prohibited:
 - (a) SUBJECT TO SEVERE PHYSICAL DAMAGE OR CORROSIVE VAPORS
 - (b) IN HOISTWAYS
 - (c) HAZARDOUS LOCATIONS
5. Ground DETECTOR and POTENTIALIZER plug should be installed on busways of ungrounded secondary systems.
6. Normal supports for a busway shall not exceed 5 feet.
7. Unbroken lengths (no joints) of busways may EXTEND through walls.
8. Busway dead ends shall be CLOSED.
9. Busways may extend through floors provided a totally ENCLOSED busway is installed up to a minimum of 6 feet above the floor for physical PROTECTION.
10. Branch circuits from busways shall be provided with PLUG - in devices.
11. Busway taps, having a minimum rating of 1/3 the ampere capacity of main duct protective devices and a maximum length of 50 feet, are not required to have OVERCURRENT protective devices.
12. Rating of the overcurrent PROTECTIVE device determines the ampere rating of the busway branch circuit.
13. The three major types of busways are:
 - (a) FEEDER DUCT
 - (b) PLUG-IN DUCT
 - (c) TROLLEY DUCT

14. Plug-in bus duct overcurrent protective devices are either:
- (a) FUSIBLE UNITS
 - (b) CIRCUIT BREAKER UNITS
15. Light duty lighting duct and trolley duct have "take-off" devices which are fused or non - FUSED or have a CIRCUIT breaker protective device.
16. One-bolt construction of modern bus duct systems require TORQUE wrenches to assure proper joint connection.
17. Busways are normally hung by what three methods?
- (a) ROD HANGERS
 - (b) CHAIN HANGERS
 - (c) TRAPESE HANGERS

ALTERNATE ANSWER: (D) MESSENGER CABLE SUPPORTS

18. Bus duct of over 600 volts shall be identified by what 7 items of information on the nameplate?
- (a) RATED VOLTAGE
 - (b) RATED CONTINUOUS CURRENT
 - (c) RATED FREQUENCY
 - (d) RATED IMPULSE WITHSTAND VOLTAGE
 - (e) RATED 60 HG WITHSTAND VOLTAGE (DRY)
 - (f) RATED MOMENTARY CURRENT
 - (g) MANUFACTURER'S NAME OR TRADEMARK

CABLEBUS

DESIRED RESULTS:

To become acquainted with the Code requirements when installing cablebus.

INTRODUCTION:

Cablebus is an approved assembly of insulated conductors mounted in a ventilated metal structure. Cablebus is generally assembled at the point of installation, from components furnished or specified by the manufacturer. These conductors are mounted in a good spaced relationship to each other. Cablebus may be used at any voltage or current for which the spaced conductors are rated. It may be installed only for exposed work.

DISCUSSION QUESTIONS:

1. Discuss the types, ampacity, size and number, and supports for conductors.
2. What overcurrent devices are used with cablebus?
3. How should cablebus conductors be supported?
4. What fittings are used in the cablebus system?
5. Discuss the terminations, grounding, and marking of the cablebus.

APPLICATION:

Have the students complete the questions for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers for discussion of errors and filing in the notebooks.

NAME _____

LESSON D-10

DATE _____

WORKSHEET

CABLEBUS

REFERENCE: National Electrical Code - Article 365.

1. Cablebus is an approved assembly of INSULATED conductors mounted in SPACED relationship in a ventilated METAL protective SUPPORTING structure.
2. The minimum wire size for cablebus conductors is #1/0 AWG.
3. The conductor insulation for cablebus conductors is 75 °C. The code designation for the insulation is XHHW.
4. The ampacity of the cablebus conductor is based on single conductors in FREE AIR, as found in tables 310-17 and 310-19 of the N. E. Code.
5. Cablebus voltage ratings are from zero volts to 35000 volts.
6. The supporting structure of cablebus can be used as an equipment GROUNDING conductor when adequately bonded.
7. The controlled spacing of cablebus conductors provides low IMPEDANCE and low VOLTAGE drop.
8. Cablebus may be installed INDOORS or OUTDOORS in either WET or DRY locations.
9. The five major steps in installing cablebus are:
 - (a) INSTALL SUPPORT SYSTEM
 - (b) PULL IN CONDUCTORS
 - (c) ARRANGE IN PROPER PHASE SEQUENCE
 - (d) SECURE TO INSULATING BLOCKS
 - (e) INSTALL TOP COVER
10. Conductor supports in cablebus are 3 feet for horizontal runs and 1 1/2 feet for vertical runs.
11. Maximum spacing of hangers for the support system shall not exceed 12 feet.
12. Approved TERMINATING means shall be used for connections to cablebus conductors.

13. Special fittings are required for the cablebus system:
- (a) HORIZONTAL AND VERTICAL CHANGES IN DIRECTION
 - (b) DEAD ENDS
 - (c) TERMINATIONS AND CONNECTIONS AT EQUIPMENT
14. Vertical and horizontal spacing between conductors is not less than one CONDUCTOR DIAMETER at the point of support.

SWITCHES

DESIRED RESULTS:

To become acquainted with the Code requirements concerning the installation and construction specifications of switches.

INTRODUCTION:

Any switch should open all ungrounded conductors of the circuit. In no case may a single-pole switch be placed in the grounded conductor. Number of poles required for switches to control three common types of circuits: (1) 2-wire single phase or D. C. circuit with one conductor grounded, (2) 3-wire single phase or D. C. circuit with grounded neutral, and (3) 4-wire three-phase circuit with grounded neutral.

Opening only the grounded wire of a two-wire circuit would leave all devices that are connected to the circuit alive. The voltage to the ground would equal the voltage between the wires on the mains. In case of an accidental ground on the grounded wire, the circuit would not be controlled by the single-pole switch.

Lamps that are connected between the neutral and the two or three outer wires of the 3-wire and 4-wire circuits are not balanced. If the neutral is then opened, it would cause the voltages to become unbalanced and might burn out all lamps on the more lightly loaded side. In any case a switch may be arranged to open the grounded conductor if it simultaneously opens all the other conductors of the circuit. Since three-way and four-way switches are actually single-pole switches, they must not be used to disconnect the grounded circuit wire because this would be a violation of Section 380-2a

A metal switch plate, if not grounded, may become "alive" by reason of contact of the ungrounded circuit wire with the plate or switch box. A hazard is thus created if the plate is within reach from any conductive object. The hazard still exists, however, if a plate of insulating material is attached by means of metal screws with exposed heads.

Rating of Snap Switches:

- a. For a noninductive load not including any tungsten-filament lamps, a snap switch is merely required to have an ampere rating at least equal to the ampere rating of the load it controls. Electrically heated appliances are common examples of such loads.

- b. For the control of loads consisting of tungsten lamps alone, and for combined tungsten-filament with any other noninductive load, snap switches should be T rated. Thus T rated switches are required in all public spaces, such as hotel lobbies, retail stores, and places of assembly.
- c. Inductive loads which are commonly controlled by snap switches are fluorescent lamps, mercury-vapor lamps, and gas-tube signs and lighting. The term "snap switch" as used here and elsewhere in the Code is the common types of flush and surface-mounted switches. They are used for the control of lighting equipment and small appliances and are generally the tumbler or toggle type switch.

DISCUSSION QUESTIONS:

- 1. Discuss the importance of grounded conductors on switches.
- 2. How are switches and circuit breakers enclosed? Are the enclosures weatherproof?
- 3. How are knife switches installed?
- 4. Give specifications of covers of flush snap switches.
- 5. How are snap switches rated?
- 6. Give some construction specifications for switches.

APPLICATION:

Have the students complete the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-11

DATE _____

WORKSHEET

SWITCHES

1. Switches shall not disconnect the GROUNDED CONDUCTOR of a circuit.
2. All switching shall be done in the UNGROUNDED conductor.
3. In conduit installations, all WIRES between switch and outlet shall be in the same raceway.
4. Switches shall be mounted in METAL BOXES and shall be EXTERNALLY operated.
5. Switches mounted outdoors shall be in WEATHERPROOF enclosures.
6. Time switches shall be enclosed in METAL BOXES.
7. Double-THROW knife switch may be mounted vertically or horizontally.
8. Single-throw knife switch shall be connected so that blades are DOWN or DEAD when the switch is open.
9. Face plates for flush mounted snap switches mounted within reach of conducting surfaces shall be made of NON-CONDUCTING material.
10. Voltage between gauged snap switches cannot exceed 300 volts unless permanently installed BARRIERS are installed between adjacent switches.
11. Switch boxes for circuits of over 150 volts to ground shall be GROUNDED.
12. Circuit breakers or switches of special design shall be installed to INTERRUPT circuits greater than 1200 amperes at 250 volts or less.
13. Isolating switches are installed to ISOLATE the circuit from the SOURCE and are intended to be operated only after the circuit has been OPENED.
14. A fused switch shall be wired so that the fuses will be DEAD when the switch is open.
15. A switch is not designed for interruption of a circuit under SHORT - CIRCUIT conditions.

16. A DOUBLE - POLE switch breaks the connection in two conductors of a circuit.
17. A DOUBLE - THROW switch will make a closed circuit when thrown in either of two positions.
18. Oil switches have contact parts IMMERSED in the liquid.
19. What two items of information appear on all switches?
- a. CURRENT RATING IN AMPERES
- b. VOLTAGE RATING

ALTERNATE ANSWER: (c) HORSEPOWER RATING IF DESIGNED FOR PURPOSE

20. Fused switches cannot have fuses in parallel. True / False TRUE
Code Reference 380-17

SWITCHBOARDS AND PANELBOARDS

DESIRED RESULTS:

To study the requirements of the Code that apply to switchboards, panelboards, and distribution boards installed for the control of light and power circuits.

INTRODUCTION AND DISCUSSION:

A switchboard as defined by the Code is a large single panel, frame, or assembly of panels, on which are mounted, on the face or back or both, switches, overcurrent and other protective devices, busses, and usually instruments.

It is difficult to define panelboard and switchboard in such a way as to make a clear-cut distinction between the two. A panelboard with its enclosing cabinet is sometimes called a panel box. Panel boxes may be of either the flush or surface type. Surface type boxes are used for installations employing exposed wiring. The boxes are generally constructed of sheet metal, which must not be less than No. 16 U. S. Standard Gage in thickness. Gutters are provided around the panelboards in panel boxes in order to allow sufficient space for wiring.

Accessibility and working space are very necessary to avoid shock hazards and to provide easy access for maintenance, repair, operation, and housekeeping. It is preferable to increase the minimum space behind a switchboard to at least 36 inches where space will permit.

DISCUSSION QUESTIONS:

1. Where should switchboards be located?
2. What are the clearance requirements when installing these boards?
3. Give several requirements concerning the installation of insulated conductors.
4. What are the grounding regulations for the board and instruments?
5. What overcurrent protection is used on the panelboards?
6. List some construction specifications required for the boards.

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-12

DATE _____

WORKSHEET

SWITCHBOARDS AND PANELBOARDS

1. PANELBOARDS shall be accessible only from the front.
2. Panelboards shall be mounted in or AGAINST a wall or PARTITION.
3. Switchboards are generally accessible from the FRONT and REAR.
4. Bus bars and conductors shall be arranged to avoid OVERHEATING due to INDUCTIVE effects.
5. There shall be a 3 foot minimum clearance above a switchboard in a room having a non-fireproof ceiling.
6. Switchboard frames shall be GROUNDED.
7. Define a lighting panelboard: HAS MORE THAN 10% OF ITS OVERCURRENT DEVICES RATED 30 AMPERES OR LESS FOR WHICH NEUTRAL CONNECTIONS ARE PROVIDED.
8. There shall be a maximum of 42 overcurrent devices in a lighting panelboard.
9. Maximum overcurrent protection of a lighting panelboard shall be 200 amperes.
10. Cabinets in wet locations shall be WEATHERPROOF.
11. Switches shall be on the LINE side of fuse.
12. Bare bus bars in panelboards shall be RIGIDLY mounted.
13. The total continuous load on an overcurrent protective device in a panelboard shall not exceed 80 percent of its rating.
14. Clear work space in front of a panelboard shall be at least 30 inches.
15. The minimum clearance behind a switchboard is 2 1/2 feet.
16. What section of the N. E. Code has the rulings on questions 14 and 15 above? 110-16

WORKSHEET

LESSON D-12

17. An equipment grounding terminal bar is required for all panel-boards. True/False. FALSE Code Reference 384-27
18. The neutral bar can be used as a terminal for equipment grounding conductors. True/False FALSE Code Reference 384-27
19. Where are the equipment grounding and neutral terminal bars bonded together? AT SERVICE ENTRANCE EQUIPMENT ONLY.

HIGH VOLTAGE EQUIPMENT AND INSTALLATION

DESIRED RESULTS:

1. To understand the general scope of this article as it applies to all circuits and equipment operated at more than 600 volts.
2. To study the provisions applicable to specific types of installations covered in other articles.

INTRODUCTION:

It is recommended that you review the articles listed in the reference sheet concerned with wiring installations and methods involved. Wiring methods that are to be used to install conductors above ground and underground should be reviewed.

The installation of equipment, indoor and outdoor work, should be given special attention. Also, much of the equipment has special provisions and instructions listed by the manufacturer. Note that some states do not have these requirements and also many states have specific requirements that are not included with the equipment. Who pays the bill for special or added materials used on the job to make installations?

Instructors should continue to search for a better way of presenting the articles of the Code. Try to make it interesting with illustrations from your experience:

PRESENTING THE LESSON:

Present the scope of this article, installations covered in other articles, wiring methods, equipment (general and special provisions), etc.

Installation of high voltage equipment is accessible to Qualified Persons Only. Present some of the "Kinks of the Electrical Trade" in the methods of installing this equipment.

APPLICATION:

Have the students complete the worksheet on the lesson and check in class.

FOLLOW-UP:

Discuss the questions most often missed and return the papers to the owners for correction and placing in notebooks for future reference.

NAME _____

LESSON D-13

DATE _____

WORKSHEET

HIGH VOLTAGE EQUIPMENT AND INSTALLATION

1. High voltage equipment and conductors must have INSULATION sufficient for the voltage employed.
2. Where bare connections and buses are used, insulation is provided by SEPARATION. The higher the voltage, the greater the SEPARATION.
3. What are the five main methods of installing above ground high voltage conductors?
 - a. IN RIGID METAL CONDUIT
 - b. CABLEBUS
 - c. METAL-CLAD CABLE
 - d. BARE CONDUCTORS OR BUSES
 - e. INSULATED WIRES
4. What are the three main methods of installing underground high voltage conductors?
 - a. RIGID METAL CONDUIT
 - b. DIRECT BURIAL CABLE
 - c. DUCT BANKS - CONCRETE ENCASED
5. What is the purpose of shielding a high voltage conductor?
TO CONFINE THE DIELECTRIC FIELD.
6. What three types of devices are used to terminate the static voltage shields on high voltage cable?
 - a. POTHEADS
 - b. TERMINATOR
 - c. STRESS CONES
7. If braid-covered insulated conductors are used for open wiring, they shall have a FLAME-RETARDANT saturant applied after installation.
8. Is the static voltage shield grounded? Yes/No YES. Give the N. E. Code article for your answer. 710-6
9. Type MV cables are rated to 35000 volts. True/False TRUE article 326-3.

WORKSHEET

LESSON D-13

10. Is a special type terminator required for metal-sheathed high voltage cable? Yes/No. YES. If so, what type? ONE WHICH WILL PREVENT MOISTURE FROM ENTERING THE INSULATION.
11. What is the major difference in the equipment installed in regular work and that of high voltage equipment? ONLY THE DIFFERENCE IN VOLTAGES.

THEATERS AND ASSEMBLY HALLS

DESIRED RESULTS:

To become acquainted with the requirements of the Code concerning the wiring methods and the use of portable electrical equipment in theaters and like buildings used for public assembly.

INTRODUCTION AND PRESENTATION:

The requirements of Article 520 shall apply to all buildings or part of a building used for dramatic, motion-picture or other shows, and public auditoriums. The motion-picture projectors and associated equipment shall comply with Article 540. The sound-reproducing equipment and its installation shall comply with Article 640.

Where only a part of a building is used as a theater, auditorium, or place of public assembly, these special requirements apply only to that part and do not necessarily apply to the entire building. A common example is a school building in which there is an auditorium used for dramatic or other performances. All special requirements of Article 520 would apply to the auditorium, stage, dressing rooms, projection room, sound reproduction equipment, and the main corridors leading to the auditorium. Other parts of the school building that do not pertain to the use of the auditorium are not controlled by this article.

Building laws usually require theaters and motion-picture houses to be of fireproof construction. Thus, most of the buildings are wired for light and power with rigid conduit and electrical metallic tubing. Small auditoriums are the exception.

Much of the stage lighting in a modern theater is provided by flood-lights and projectors mounted in the ceiling or on the balcony front. In order that the projectors can be adjustable in position, they may be connected by plugs and short cords to suitable receptacles. The term gallery receptacles should include all receptacles, wherever they can be located, that are intended for the connection of stage lighting equipment. Circuits to such receptacles must be controlled at the stage switchboard where other stage lighting circuits are controlled.

A stage switchboard must have no live parts on the front, and the back must be guarded to keep all unauthorized persons away from it. The more important stage switchboards are of the remote-control type. Pilot switches mounted on the stage board control the operation of contactors installed usually below the stage. The stage switchboard is generally built into a recess in the wall. After passing through

the switches and dimmers, many of the main circuits must be subdivided into branch circuits so that no circuit will be loaded to more than 20 amperes.

Modern type footlights are mounted in the face of a sheet metal trough construction containing the circuit conductors. Each lamp is provided with an individual reflector and glass color screen. Footlights of the disappearing type should be arranged so that the current supply will be automatically disconnected when they are placed in the recess.

Border lights are usually hung on steel cables so that their height can be adjusted in order that they can be lowered to the stage for cleaning and replacing lamps and color screens. The circuit conductors supplying the lamps must be carried to the border through a flexible cable.

Portable stage equipment, lanterns, or similar devices are likely to be made of paper or other inflammable material. The lamps used in this equipment and in dressing rooms should be provided with guards that cannot be removed to prevent them from coming in contact with flammable material.

DISCUSSION:

Discuss the requirements of each section of this article and the references to other articles pertaining to the wiring of theaters and assembly halls.

APPLICATION:

Have the students complete the worksheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-14

DATE _____

WORKSHEET

THEATERS AND ASSEMBLY HALLS

1. What types of public buildings are covered under Article 520?

- | | |
|--------------------------------|------------------------------|
| a. <u>DRAMATIC SHOWS</u> | f. <u>NIGHT CLUBS</u> |
| b. <u>OPERATIC SHOWS</u> | g. <u>DANCE HALLS</u> |
| c. <u>MOTION PICTURE SHOWS</u> | h. <u>ARMORIES</u> |
| d. <u>SPORTING ARENAS</u> | i. <u>BOWLING ALLEYS</u> |
| e. <u>PUBLIC AUDITORIUMS</u> | j. <u>TELEVISION STUDIOS</u> |

2. Wiring shall be installed in metal RACEWAY, type MI cable, or type MC cable.

3. Maximum conductor fill of raceways shall not exceed 20 percent of the interior cross-section area of the raceway.

4. Maximum conductor fill of a GUTTER or WIREWAY shall not exceed 20 percent of the interior cross-section area of the GUTTER or WIREWAY.

5. Stage switchboards shall be the DEAD - FRONT type.

6. Stage switchboards shall contain OVERCURRENT protection and CONTROL for all stage receptacles.

7. Maximum overcurrent protection for a dimmer shall be 125 percent of the dimmer rating.

8. The circuit supply AUTOTRANSFORMER type dimmers shall not exceed 150 volts between conductors.

9. Maximum loading for a footlight circuit shall not exceed 20 amperes.

10. Minimum conductor insulation for border lights shall have temperature rating 125° C. (257° F.).

11. Supply cables to border lights shall be Types S, SO, or ST flexible cord.

12. Minimum rating for arc lamp receptacles shall be 50 amperes; minimum wire size shall be # 6 AWG.

13. Minimum rating for INCANDESCENT lamp receptacles shall be 20 amperes; minimum wire size shall be # 12 AWG.
14. Plugs for ARC and INCANDESCENT receptacles shall not be interchangeable.
15. Portable switchboards shall be supplied from SPECIAL PURPOSE outlets.
16. All SWITCHES and CIRCUIT BREAKERS in portable switchboards shall be externally-operable, enclosed type.
17. Minimum rating for receptacles in portable plugging box shall be 30 amperes.
18. The female half of the cable connector shall be attached to the LINE end of the cord.
19. Pendant lampholders shall not be installed in DRESSING rooms.
20. All LIGHTS and RECEPTACLES in dressing rooms shall be controlled by wall switches.
21. Each SWITCH controlling receptacles in a dressing room shall be provided with a PILOT LIGHT.

COMMUNICATION CIRCUITS

DESIRED RESULTS:

To become acquainted with the provisions of the Code as they apply to telephone, telegraph (except radio), district messenger, fire and burglar alarms, and similar central station systems.

INTRODUCTION AND DISCUSSION:

- A. General: The following sections of this chapter on communication systems apply only to those systems which are connected to a central station and operate as parts of a central station system.
- B. Protection: A protector approved for the purpose should be provided on each circuit, aerial or underground, so located in a portion of a city, town, or village. They shall be located in or on the building as near as practicable to where the conductors enter. The conductors should not come in contact with light or power conductors operating at a potential exceeding 300 volts. The protector should not be located in any hazardous location, nor near easily ignitable materials. The protector should be mounted on a noncombustible insulating base, consisting of an arrestor, a ground, and a fuse in each live conductor. A protector without fuses can be used under conditions described in Article 800.
- C. Outside conductors:
 - 1. Where overhead communication conductors and light or power conductors are supported by the same pole.
 - a. They should be located below the light and power conductors.
 - b. They should not be attached to a crossarm which carries light or power conductors.
 - c. A climbing space is needed in order to avoid danger to the linemen.
 - 2. Conductors passing over buildings should be at least 8 feet above any roof, except small auxiliary buildings.
 - 3. Circuits which require protectors shall comply with the Code.
 - a. Each conductor should have 1/32-inch rubber insulation.
 - b. Conductors within a cable of metal-sheathed type conduit should have 1/32-inch rubber insulation, and should be covered with a substantial fibrous material.
 - c. On buildings, open conductors should be separated at least 4 inches from light and power conductors not in a conduit or cable. They should be placed on insulating supports.

- d. The conductors should enter the building through an insulating bushing or metal raceway, where the protector is installed inside.

D. Underground circuits:

1. Underground communication conductors in a duct or manhole containing electric light and power conductors should be separated by means of brick, concrete, or tile partitions.
2. Where the entire street circuit is run underground, the circuit within the block is placed as to be free from liability of accidental contact with electric light or power circuits.

E. Grounding:

Equipment should be grounded as follows:

1. The metal sheath of aerial cables entering buildings should be grounded.
2. The protector ground should comply with the following:
 - a. The grounding conductor should have 1/32-inch rubber insulation.
 - b. The conductor should not be smaller than No. 18 copper wire.
 - c. The grounding conductor should be run in as straight a line as practicable to the grounding electrode.
 - d. The grounding electrode should be guarded from physical damage.
 - e. The grounding conductor should preferably be connected to a water pipe electrode.
 - f. The conductor should be attached to a pipe electrode by means of a bolted clamp to which the conductor is connected.

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return to the students for correction and placing in their workbooks.

NAME _____

LESSON D-15

DATE _____

WORKSHEET

COMMUNICATIONS CIRCUITS

1. What types of communications circuits are covered by Article 800 of the N. E. Code?
 - a. TELEPHONE
 - b. TELEGRAPH
 - c. DISTRICT MESSENGER
 - d. FIRE ALARM
 - e. BURGLAR ALARM
2. Underline correct words to make true statements:

These systems (are / are not) connected to a central station and they (do / do not) use similar types of equipment, methods of installation and maintenance.
3. An approved protector shall be installed on each AERIAL or UNDERGROUND circuit.
4. The PROTECTOR shall be located in or on the building near to the point where the CONDUCTORS enter.
5. The protector shall not be installed in HAZARDOUS LOCATIONS.
6. The protector shall be mounted on a non-COMBUSTIBLE, non-ABSORPTIVE insulating base.
7. The protector shall consist of an ARRESTER in each LINE conductor.
8. An ARRESTER shall be installed between each LINE conductor and the ground.
9. Open conductors shall be separated at least TWO inches from any light or power conductors not in METALLIC raceways.
10. Communications conductors shall not be installed in the same raceway, OUTLET box, compartment or JUNCTION box with conductors for light and power circuits.
11. Conductors bunched together in a vertical run in a shaft shall have a FIRE - RESISTANT jacket.

WORKSHEET

LESSON D-15

12. OVERHEAD communications conductors shall be installed BELOW the light and power conductors.
 13. Conductors shall not be attached to a CROSS ARM which carries LIGHT and POWER conductors.
 14. Conductors passing over buildings shall be kept a minimum of 8 feet above any roof.
 15. Open conductors on buildings shall be separated at least 4 inches from light or power conductors not in CONDUIT or CABLE.
 16. If the protector is installed inside the building, the conductors shall enter through an insulating BUSHING or in a METAL raceway.
 17. A minimum separation of SIX feet shall be maintained between open communication conductors and lightning conductors.
 18. Underground conductors in a manhole shall be installed in a SEPARATE SECTION from the light or power conductors.
 19. Metal sheath of aerial cables entering a building shall be GROUNDED.
 20. The minimum protector grounding conductor shall be No. 18 copper.
 21. The grounding conductor shall be guarded from PHYSICAL DAMAGE.
 22. The grounding conductor shall be run in a STRAIGHT LINE to the grounding electrode.
 23. The grounding conductor shall be connected to a GROUNDING ELECTRODE.
 24. The grounding conductor shall be attached to a pipe electrode by a BOLTED CLAMP.
 25. Why should all grounding electrodes be bonded together? TO LIMIT THE
POTENTIAL DIFFERENCE BETWEEN THE GROUNDING ELECTRODE AND THEIR
ASSOCIATED WIRING SYSTEMS.
- Give the N. E. Code Article which allows this. 250-86

RADIO AND TELEVISION EQUIPMENT

DESIRED RESULTS:

To become acquainted with the requirements of the Code concerning radio and television receiving equipment, and amateur radio transmitting and receiving equipment.

INTRODUCTION:

For service drops and conductors on the exterior of buildings, the requirements for insulating covering and methods of installation depend upon the liability of crosses occurring between the signal conductors and the light or power conductors. Where communication wires are run on poles in streets, it is assumed that they are exposed to contact with other wires; 1/32-inch insulation is required. Where the overhead wires are run in an alley or from building to building and kept away from streets, lighter weight insulation is permitted. Some communication systems are connected to a distribution system that is entirely underground except within the block in which the building is located. Any overhead wires in alleys or attached to buildings are not liable to become crossed with light and power wires. The restrictions as to insulating covering and methods of installation are eliminated.

Lead-in conductors for antenna systems should have adequate strength and corrosion resistant qualities. In the event that a broken wire might come in contact with a light or power wire, this will ensure continuity of service. It is important that all possible precautions be taken to prevent the possibility of a cross between a radio antenna and a light or power conductor.

Most of the antennas for television reception that are supported on metal structures must be grounded to protect them from lightning. Grounding must be done in accordance with the Code, Article 250. It is good practice to use the same ground electrode for the grounding of masts as is used for the electrical system of the building.

DISCUSSION QUESTIONS:

1. Discuss the materials used in antenna systems and things to avoid in the installation.
2. List important factors to consider in grounding radio and television equipment.

3. Discuss how the interior installation at transmitting stations should comply with the Code.

APPLICATION:

Have the students complete the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in their workbooks.

NAME _____

LESSON D-16

DATE _____

WORKSHEET

RADIO AND TELEVISION EQUIPMENT

1. Article 800 shall not apply to equipment for coupling CARRIER
CURRENT to power line conductors.
2. Radio noise suppressors shall be an APPROVED TYPE
for the purpose.
3. Radio noise suppressors shall not be exposed to PHYSICAL
DAMAGE.
4. Lead-in conductors with spans less than 35-feet may be SOFT
DRAWN or MEDIUM DRAWN copper.
5. Outdoor CONDUCTORS shall be securely supported.
6. Hard DRAWN copper shall be used for antenna conductors.
7. Lead - IN conductors shall be securely ATTACHED
to the antenna.
8. Outdoor antenna conductors shall not cross over LIGHT or
POWER conductors.
9. Splices and TAPS may be made in antenna spans.
10. Antenna masts shall be permanently GROUNDING.
11. Minimum size hard-drawn copper conductors permitted for receiving
station outdoor antenna shall be No. 19 AWG.
12. Outdoor antennas shall be designed to withstand ICE and
WIND loading conditions.
13. Minimum distance between open conductors of a communication system
on buildings and lightning system conductors shall be at least
6 feet.
14. In general, the minimum distance between indoor antenna and power
conductors shall be 2 - inches.
15. Each outdoor lead-in conductor shall be provided with a LIGHTNING
ARRESTER.
16. Lightning arresters shall be located OUTSIDE the building.

17. Lightning arresters shall be located near NON - COMBUSTIBLE material and shall not be installed in HAZARDOUS LOCATIONS.
18. The grounding conductor shall be of COPPER.
19. The grounding conductor may be INSULATED or BARE.
20. The grounding conductor shall be installed in a STRAIGHT LINE between the antenna and grounding electrode.
21. The grounding conductor shall be connected to a METALLIC PIPE underground electrode by means of a BOLTED CLAMP.
22. Receiving station grounding conductors may be installed INSIDE or OUTSIDE the building.
23. The minimum size receiving station grounding conductor shall be No. 10 AWG (copper).
24. One receiving station grounding conductor may be used for PROTECTIVE and OPERATING purposes.
25. The minimum size hard-drawn copper conductor for amateur transmitting systems shall be No. 14 AWG.
26. Minimum building clearance for amateur transmitting antenna conductors shall be 3 -inches.
27. Each lead-in conductor for an outdoor amateur transmitting antenna shall be provided with a LIGHTNING ARRESTER.
28. The minimum size protective ground conductor for amateur transmitting stations shall be No. 10 AWG (copper).
29. The minimum size operating grounding conductor for transmitting stations shall be No. 14 (copper).
30. Transmitters shall be enclosed in a METAL frame.
31. All external metallic handles and controls on a transmitter shall be GROUNDED.
32. Interlocks shall be provided on all TRANSMITTER access doors.
33. Remote audio-amplifiers shall be ACCESSIBLE and VENTILATED.

DATA PROCESSING EQUIPMENT

DESIRED RESULTS:

1. To become acquainted with the equipment, power supply wiring, equipment interconnecting wiring and grounding of data processing systems.
2. To study the Code to understand the three methods of connecting data processing systems.

INTRODUCTION:

The provisions of this Article shall apply to equipment, power supply wiring, equipment interconnecting wiring, and grounding of the data processing systems including data communications equipment used as a terminal unit.

PRESENTING THE LESSON:

1. Give the scope and definitions needed.
2. Review the Code concerning supply circuits and interconnecting cables.
3. Discuss the disconnecting means:
 - a. In Data Processing rooms
 - b. In general building areas
4. Refer to the grounding in accordance with Article 250
5. Markings
 - a. Manufacturers name plate
 - b. Items to be listed on nameplate are rating in volts, the operating frequency, and the total load in amperes.

APPLICATION:

The student should complete the worksheets and exchange papers for checking.

FOLLOW-UP:

Return checked papers to the owners for discussion, correction and filing in notebooks.

NAME _____

LESSON D-17

DATE _____

WORKSHEET

DATA PROCESSING EQUIPMENT

1. Article 645 of the N. E. Code applies to the following items of data processing systems:
 - (a) POWER SUPPLY WIRING
 - (b) EQUIPMENT
 - (c) EQUIPMENT INTERCONNECTING WIRING
 - (d) GROUNDING
 - (e) DATA COMMUNICATIONS EQUIPMENT
2. The ampacity of the branch circuit conductors supplying data processing equipment shall be at least 125 percent of the total CONNECTED LOAD.
3. What are three methods of connecting data processing systems to their power supply?
 - (a) COMPUTER CABLE
 - (b) FLEXIBLE CORD
 - (c) CORD SET ASSEMBLY
4. Computer cords and cables may be run on the surface of a floor if PROTECTED from physical DAMAGE.
5. Computer cables can be installed under a raised floor. Yes/No YES
Article Reference 645-2 (c) (1).
6. Branch circuit supply conductors installed under a raised floor feeding receptacle shall be installed in:
 - (a) RIGID CONDUIT
 - (b) ELECTRICAL METALLIC TUBING
 - (c) FLEXIBLE METAL CONDUIT
 - (d) TYPE MI CABLE
 - (e) TYPE ALS CABLE OR CS CABLE
7. Power and communication supply cables may be installed under a raised floor without any ventilation. Yes/No NO. Give the N. E. Code section for your answer 645-2 (c).
8. What two systems must be provided with a disconnecting means readily accessible within the data processing room?
 - (a) VENTILATION SYSTEM
 - (b) POWER TO ALL ELECTRICAL EQUIPMENT WITHIN ROOM EXCEPT LIGHTING

9. Data processing equipment grounding shall conform to what Article of the N. E. Code? ARTICLE 250
10. List the three items of information which must be shown on each item of electrical data processing equipment.
- (a) RATING IN VOLTS
 - (b) OPERATING FREQUENCY
 - (c) TOTAL LOAD IN AMPERES

LOW VOLTAGE SYSTEMS

DESIRED RESULTS:

To study the provisions of the Code that apply to low voltage systems, such as remote-control circuits, low-voltage relay switching, low energy power circuits, low voltage circuits, and signal circuits.

INTRODUCTION:

The provisions of this Article are not intended to apply to remote-control, low-energy or signal circuits which form an integral part of a device or appliance.

Circuits or equipment coming within the scope of this Article and installed in hazardous locations shall also comply with the appropriate provisions of Articles 500 through 517.

PRESENTING THE LESSON:

This Article 725 is divided into the following parts:

- A. Scope and General
- B. Class I System
- C. Limitations of Low-voltage Power Circuit
- D. Class II System Voltage and Current Limits
- E. Installation of Class II Remote-Control and Signal Circuits

Discuss the significant aspects of each section of the Article 725.

APPLICATION:

The students should complete the worksheet for this assignment and ask questions concerning the provisions of the Article that are vague to them.

CHECKING AND FOLLOW-UP:

Exchange papers and check the answers. Return papers to the owners for correction, discussion and placing in their notebooks.

NAME _____

LESSON D-18

DATE _____

WORKSHEET

LOW VOLTAGE SYSTEMS

1. Give two examples of low energy power circuits:

(a) ELECTRIC DOOR OPENERS

(b) ELEVATOR CONTROLS

2. Low energy circuits have the POWER limited and are considered Class 2 remote-control circuits.

3. Low voltage power circuits have the CURRENT limited and are considered Class 1 remote-control circuits.

4. Safety control circuits are considered as Class 1 remote-control circuits.

5. Wiring methods in general for a Class I remote-control circuit shall conform to Chapter 3 of the N. E. Code.

6. Conductor sizes are usually No. 18 or No. 16 AWG.

7. Multiple signal and/or power remote control circuit conductors can be installed in the same RACEWAY providing all conductors are INSULATED.

8. Why are conductors for low voltage systems more likely to become damaged during installation than regular wires? BECAUSE THEY ARE SMALLER SIZE (16 OR 18 GAGE) AND THE INSULATION IS THINNER.

9. What is the maximum overcurrent protection which can be used for a No. 18 or No. 16 low voltage system conductor? 20 Amps.

10. Where are the overcurrent protective devices for low voltage systems generally located? WHERE THE CONDUCTOR RECEIVES ITS SUPPLY.

11. Because of the low voltages involved, are these type circuits and equipment required to be grounded? Yes/No YES. Give the N. E. Code Article for your answer 725-20 & 750-42.

12. Match the proper voltage with the limiting current for Class II systems.

<u>Column A Voltage</u>		<u>Column B Low Current</u>
<u>2</u>	(a) Maximum 15 volts	1. One ampere
<u>5</u>	(b) 15 to 30 volts	2. 5 amperes
<u>3</u>	(c) 30 to 60 volts	3. 1.6 amperes
<u>1</u>	(d) 60 to 150 volts	4. 5 milliamperes
<u>4</u>	(e) Maximum 150 volts	5. 3.2 amperes
		6. 15 amperes

13. Maximum line side protection for a Class II remote-control system transformer is 20 amperes.

14. Outside installation of Class II remote-control system wiring requires lightning protection, Yes/No YES. Give the N. E. Code section for your answer 725-41 AND 800-7.

ANALYSIS OF CONTROL CIRCUITS

DESIRED RESULTS:

1. To be able to analyze circuits developed by someone else.
2. To be able to understand as much as possible about the operation of the machine which the motor drives, so that the function of the circuit can be analyzed.
3. To be able to make schematic drawings properly in order to help analyze the circuits.

INTRODUCTION:

The student who wishes to obtain proficiency in analysis of control circuits must be able to apply the basic principles to other circuits that are at his disposal. He should practice with these circuits until he is satisfied that he can, with reasonable speed, interpret and analyze control circuits of all types.

The danger in circuit analysis work lies in the tendency to jump at conclusions. The worker will decide what the circuit does and how it operates when he has checked only a part of its possibilities. He should learn to study a circuit, contact by contact and coil by coil, until he has analyzed it from beginning to end.

PRESENTING THE LESSON:

The basic procedure for circuit analysis is very simple and should be readily understood if the student has mastered the material on control circuit development. The learner should consider the circuit one part at a time and decide what happens if a contact closes or opens a circuit. When relays are used in the circuit, he should be sure that each contact which is closed or opened by that relay is considered. When analyzing a circuit, he should be sure that every component in its normal and energized positions is checked out so that the entire circuit is understood.

Analyze the following circuits shown in the text using a step-by-step method. This practice should give the student the basic fundamentals of analyzing control circuits so that he can apply the knowledge in actual job situations.

Refer to the text for illustrations:

1. Forward and reverse control for a single motor.
2. Start, stop, and jog service for a single motor using a jogging relay.

3. Dynamic braking for a squirrel-cage motor.
4. A wye-delta controller for a squirrel-cage motor.
5. Primary-resistance reduced voltage starter.
6. Lockout circuit.

Obtain additional drawings of circuits and practice analyzing them until the students become proficient. The ability to analyze a circuit is a prerequisite to any efficient troubleshooting on motor control circuits.

APPLICATION:

Have the students complete the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-19

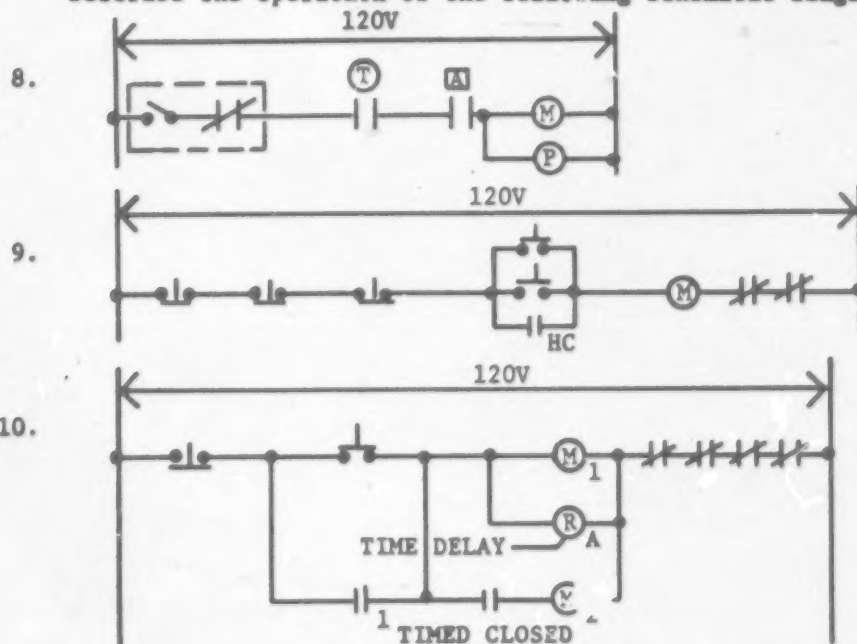
DATE _____

WORKSHEET

ANALYSIS OF CONTROL CIRCUITS

1. A motor circuit should be converted to a SCHEMATIC DIAGRAM in order to analyze it.
2. In an analysis of a control circuit, always consider the circuit ONE COMPONENT at a time.
3. A repairman should always consider every component of a circuit in its NORMAL and ENERGIZED positions.
4. Be systematic in the study of a circuit contact by CONTACT and coil by COIL.
5. Always study a control circuit through its normal sequence from LEFT to RIGHT.
6. For the inexperienced workman, what is the greatest danger in circuit analysis? JUMPING TO CONCLUSIONS
7. A good troubleshooter has the ability to ANALYZE the control circuit and determine quickly which COMPONENT is causing the malfunction of the equipment.

Describe the operation of the following schematic diagrams:



MAINTAINING CONTROL EQUIPMENT

DESIRED RESULTS:

1. To acquaint the apprentice with some of the basic principles of good maintenance.
2. To teach that preventative maintenance is inspecting, cleaning, and keeping the control equipment tight and not repairing.

INTRODUCTION:

This lesson should point up some of the basic principles of good maintenance. The actual maintenance of a specific piece of equipment must be determined by its operating cycle, complexity of its components, and the time available for its care. Maintenance means to maintain the equipment in operating condition as compared with repairing the equipment after it has broken down.

The greatest causes of failure of control systems are dust, grease, oil, and dirt, which should be removed at regular intervals. This is called preventative maintenance. There should be scheduled inspection dates to prevent serious breakdowns.

There is a single rule which applies to all electrical maintenance work and under all conditions. The rule is be careful. Carelessness and failure to observe electrical safety rules are two bad habits maintenance men cannot afford.

PRESENTING THE LESSON:

- I. The first procedure in any organized maintenance of equipment program should be periodic inspection.
 - A. Remove dust, grease, oil, and dirt with a solvent. Provide adequate ventilation.
 - B. Check for excess heat of bearings, coils, contacts, and transformers.
 - C. Lubricate bearings of motors and mechanical equipment.
 - D. Check for loose bolts and nuts on electrical connections and on the equipment.
 - E. Use a meggar insulation tester on motors and cables.
- II. There are two laws to follow in preventative maintenance:
 - A. Know your equipment mechanically and electrically so that you can sense trouble before it develops.

- B. Be observant. Whenever you pass a piece of equipment for which you are responsible, inspect it.

NOTE: Good maintenance can be summed up in the following words: Keep it tight, keep it clean, keep it lubricated, and inspect it frequently.

III. Call attention to the maintenance of the following equipment:

- A. Motor starters and causes of trouble
 - 1. Improper adjustment of contacts and time-delay circuits
 - 2. Coil burnout
 - a. Failure of the contactor magnet circuit to close
 - b. Improper voltage
- B. Relays--Maintenance essentially same as motor starter and contactors
- C. Pilot devices--Check mechanical operation and contact condition
- D. Brakes and clutches
 - 1. Replace worn brake lining
 - 2. Wear and improper adjustment of linkage

APPLICATION:

Have the students complete the Assignment Sheet questions for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and have the students make corrections and place the sheets in their workbooks.

NAME _____

LESSON D-20

DATE _____

WORKSHEET

MAINTAINING CONTROL EQUIPMENT

1. Maintenance means to MAINTAIN the equipment in OPERATION.
2. Maintenance is to clean it, TIGHTEN it, LUBRICATE it, and INSPECT it frequently.
3. The chief cause of brake failure is worn brake LINING or brake DISKS.
4. BRAKE LINING should never be allowed to reach the dangerous condition of wear.
5. Improper LINKAGE adjustment is a frequent cause of coil burn-out on brake solenoids.
6. Plant maintenance men must think SAFETY.
7. Carelessness and FAILURE to observe SAFETY precautions are two things that maintenance men cannot afford.
8. List two purposes of a periodic inspection:
 - a. CLEAN EQUIPMENT OF DUST, DIRT, GREASE, AND OIL
 - b. CHECK FOR OVERHEATING OF ELECTRICAL EQUIPMENT & MECHANICAL PARTS
9. The greatest causes of control system failures are DUST and DIRT; GREASE and OIL.
10. Bearings of MOTORS and mechanical EQUIPMENT should be checked for proper lubrication.
11. Short circuits and grounds may be prevented by the proper inspection of insulation and by using a MEGGAR tester.
12. The first law of maintenance is to KNOW YOUR EQUIPMENT.
13. The second law of maintenance is to be a good OBSERVER.
14. Motor starter failure is due frequently to CONTACT TROUBLE.

15. A repairman should never file SILVER contacts.
16. Excessive arcing and pitting is caused by improper ALIGNMENT or lack of contact PRESSURE.
17. List two major causes of automatic equipment failure:
- a. IMPROPER ADJUSTMENT OF CONTACTS
 - b. TIME-DELAY CIRCUITS
18. List two major causes of coil burnouts:
- a. FAILURE OF MAGNET CIRCUIT TO CLOSE
 - b. IMPROPER VOLTAGE
19. Overload relays should be tripped by CURRENT periodically to check proper operation.
20. Current relays should be checked for proper amount of CURRENT.
21. Time delay relays should be ADJUSTED periodically.
22. Pilot devices require very little MAINTENANCE.
23. Limit switches are prone to MECHANICAL FAILURE.

CHECKING PROCEDURE:

If it is believed that the coil is at fault, disconnect the power and use an ohmmeter to check the resistance of the coil. If the coil is burned out, there will be a high resistance reading, or a reading of infinity on the ohmmeter.

If the voltage check showed that the voltage did not reach the coil when it should in the sequence of operation of the control circuit, this indicates that some contact is not closing when it should or is coated with copper oxide or other insulating material. The other possibility is an open circuit caused by a broken or burnt wire. This is the least likely cause of trouble. Having checked the contacts and eliminated the trouble, proceed to the next section of the control which does not function.

The above procedure is based on years of experience and an understanding of the fact that control circuits are made up of only two things:

- (1) Contacts which make and break the circuit.
- (2) Coils which operate these contacts.

The most important rule in troubleshooting is to change only one thing at a time. Try the circuit again before changing anything else.

The best equipment for efficient and proper troubleshooting of individual components is a complete knowledge of their proper operation and a familiarity with as many manufacturers' versions of each component as possible. No matter how complex the control circuit, the efficient troubleshooter will narrow his trouble down to one of the simple branches.

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

TROUBLESHOOTING CONTROL CIRCUITS

DESIRED RESULTS:

1. To determine the section of the control circuit that contains the trouble.
2. To select the proper component or simple branch to be checked.

INTRODUCTION:

Some men who can do an excellent job of wiring from a circuit diagram are lost if the circuit fails to function. The secret to efficient and accurate troubleshooting lies in determining the section of the control circuit that contains the trouble component and then selecting the proper component to be checked. This can be accomplished by efficient and accurate circuit analysis, not by trial and error.

GENERAL PROCEDURE:

The first procedure should be to analyze the circuit to determine whether or not it has been properly designed and installed. The next step is to follow the operation of the equipment through the expected sequence until the section of the circuit which is not properly operating is found. It should be a simple procedure to check the wiring and operation of the components involved in this section of the circuit and correct the trouble.

TROUBLESHOOTING AN EXISTING CIRCUIT:

The first step in troubleshooting an existing circuit which has developed trouble is to understand the circuit and the operation of the machine it controls. With the help of the operator, the machine can be followed through its cycles until it reaches the point where it does not function properly. A careful check of this circuit will generally lead to the source of the trouble. The first step is to locate the components involved in this part of the circuit. There must be a coil of a relay, a contactor, or some other device which is energized by this section. The machine should be run through its sequence to determine if this coil receives energy and if the contactor or relay does not close as it should. The circuit should be disconnected and the wires removed from the coil of the relay or contactor so that a voltage check can be taken. If the voltmeter indicates the proper voltage has been applied, then the trouble may be in the windings of the coil itself.

NAME _____

LESSON D-21

DATE _____

WORKSHEET

TROUBLESHOOTING CONTROL CIRCUITS

1. Troubleshooting control work requires a SPECIALIZED person.
2. Troubleshooting of control circuits requires an analytical mind trained in all the aspects of control FUNCTIONS, COMPONENTS, CIRCUITS, and circuit ANALYSIS.
3. Efficient troubleshooting is accomplished by EFFICIENT and ACCURATE circuit analysis.
4. Initial checking of all connections in all the wiring is troubleshooting by TRIAL and ERROR.
5. The initial step in troubleshooting is to ANALYZE the CIRCUIT.
6. The second step is to follow the operation of the EQUIPMENT through the expected SEQUENCE to find the SECTION of the circuit that is malfunctioning.
7. Lack of KNOWLEDGE of control functions, control components, control circuits or circuit analysis will cause undue DELAY and WASTE of time.
8. Remember that the circuit operated originally, and it must have been PROPERLY wired.
9. A good troubleshooter must understand the CONTROL circuit and the OPERATION of the machine.
10. We analyze the CIRCUIT to determine the malfunctioning CONTROL component causing the circuit failure.
11. The coil should be removed from the circuit to make a VOLTAGE check.
12. A high RESISTANCE reading on a coil indicates the coil must be replaced.
13. Control circuits are made up basically of CONTACTS and COILS.
14. A basic rule in troubleshooting is to CHANGE only one thing at a time.

WORKSHEET

LESSON D-21

15. Do not underestimate the value of the EQUIPMENT OPERATOR in determining the cause of the trouble.
16. All failures of electric control circuits are not necessarily caused by ELECTRICAL trouble.
17. A troubleshooter should be equipped with the following testing meters: VOLTMETER, AMMETER, and an OHMMETER.
18. When inspecting a magnetic starter, check the OVERLOAD RELAYS for tripping.
19. Always check the VOLTAGE feeding the coils of a relay.
20. The repairman should change only the CONTROL COMPONENT that is causing the circuit to malfunction.

PRINCIPLES OF STATIC CONTROL

DESIRED RESULTS:

1. To understand the meaning of static control and to learn to read static control or logic diagrams.
2. To understand the basic functions and the parts of a static control system.

INTRODUCTION:

In previous lessons the language of control by relays and moving contact has been discussed. Now it is necessary to convert this language into one that will apply to static control ideas. The language of static control and its circuit requirements are expressed in terms of logic functions. Until recently, this type of control was limited in use to automation in plants. However, it appears that most single machines are using static control as part of their built-in system. Static control is the term used to define a system of machine or process control which uses no moving parts or electrical contacts.

PRESENTING THE LESSON:

I. Elements of static control

The four logic elements are and, not, or, and memory. Typical symbols for these elements are shown in Figure 10-1 of the text. Basically, these logic functions are fulfilled by the four logic elements and a time delay. Any explanation of the control of a machine can be expressed in terms of the logic relationships of each function.

1. Present logic element symbols (Figure 10-1)
2. Discuss inputs and outputs
3. Show the progressive steps in designing a circuit
 - a. Use Figures 10-2, 10-3, 10-4, and 10-5
 - b. Use Figures 10-6, 10-7, and 10-8

II. Why static control

The subject of control can be broken down into three parts: information, decision, and action.

1. Information--Sensing devices: Limit switches, push buttons, pressure switches temperature sensors.

2. Decision or "brains"--Assimilate and correlate
3. Action
 - a. Solenoid valve
 - b. Contactor or starter
 - c. Indicating light

Static control seems to be the best method of achieving the three main objectives we have discussed. Magnetic amplifiers and other static devices have in common a characteristic of operation which is basically different than that of relays. This difference is that static devices may have one or more inputs and a single output. Relays have a single input to the coil and one or more outputs, depending on the number of contacts used. A different approach is employed in designing control systems using static devices. The computer specialists faced this problem when they had to convey information using vacuum tubes. They devised a way of assimilating information and arriving at decisions by a system of logic functions. They showed that all intelligence could be broken down into five basic logic functions, each having one or more inputs and a single output.

III. Theory of logic function

1. The first function is and.
2. The second logic function is the or.
3. The third logic function is not.
4. The fourth function is memory.
5. The fifth function is delay.

IV. Application of static elements

Trace the development of the desired operating cycle requirements to control a planer table. Use reference figures and illustrations in the text.

1. Step 1 - Planer-table circuit
2. Step 2 - Planer-table circuit
3. Planer-table circuit, complete

APPLICATION:

Have the students complete the problems and questions for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-22

DATE _____

WORKSHEET

PRINCIPLES OF STATIC CONTROL

1. A system of machine control which utilizes no MOVING parts or ELECTRICAL contacts is defined as static control.
2. The life of a control system is increased by the use of SOLID STATE devices.
3. Static control and its circuit requirements are expressed in terms of LOGIC functions.
4. List five elements of logic functions:
 - a. AND
 - b. OR
 - c. NOT OR NOR
 - d. MEMORY
 - e. DELAY
5. The subject of "static control" can be broken down into three parts:
 - a. INFORMATION
 - b. DECISION OR "BRAINS"
 - c. ACTION
6. A static control device that will provide an output after a lapse of time when it received one or more inputs is called a TIME DELAY element.
7. A conventional control circuit expressed in different terms is similar to a LOGIC FUNCTION.
8. The oldest method of static control uses VACUUM TUBES.
9. The most reliable static control uses MAGNETIC amplifiers in conjunction with rectifiers, CAPACITORS and RESISTORS.

10. The "Information Section" of a machine is called SENSING DEVICES.
11. The "Decision Section" RECEIVES and TRANSMITS the information.
12. The "Action Section" operates an AMPLIFIER to produce the desired results.
13. Until automation arrived, the "Decision Section" was made with RELAYS.
14. Logic devices may have one or more INPUTS and a single OUTPUT.
15. The output of a magnetic amplifier is less than ONE watt.
16. Each MANUFACTURER of a static control system uses its own ideas.
17. Draw the symbols for each of the five elements of logic functions and the amplifier.



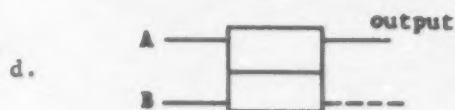
AND



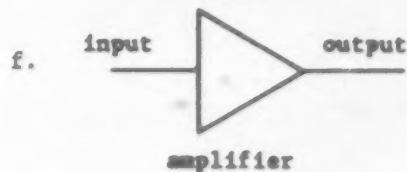
OR



NOT



DELAY



amplifier

TRANSISTORS AS LOGIC ELEMENTS

DESIRED RESULTS:

1. To acquaint the students with the use of transistorized logic elements in custom-designed circuitry.
2. To illustrate the use of transistors and diodes as found in logic circuitry.

INTRODUCTION:

The third static control system we shall discuss is one using transistorized logic elements in custom design circuitry. The transistor is the latest and newest of the relay type control devices. It is defined as a three element semiconductor amplifying device. The three elements are called the collector, base, and emitter named from their functions. Invented in 1948, the transistor is mechanically strong, compact, cheap, and long-lived. Operation is very fast, comparable in speed for control purposes with vacuum tubes. Currently available transistors will handle 20 to 50 volts and new ones up to 450 volts. Thus, the logic part of the control circuit uses transistors, but the final closure of the power circuit to the motor must use a relay or contactor.

PRESENTING THE LESSON:

1. In order that the student understand the logic circuit, discuss some basic facts of transistors and the proper handling of them.
2. Discuss how transistors may be ruined by certain incorrect electrical conditions.
 - a. Over voltage
 - b. High temperature
 - c. Wrong polarity of collector voltage
3. Consider several elementary transistor circuits, using drawings in Figures 12-5 and 12-6a. or others.
4. Discuss amplifier action in transistors by referring to Figure 12-6b and 12-6c or others.
5. Consider the transistor in some possible logic circuits. Refer to Figure 12-7, Figure 12-8, and others.

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in their workbooks.

NAME _____

LESSON D-23

DATE _____

WORKSHEET

TRANSISTORS AS LOGIC ELEMENTS

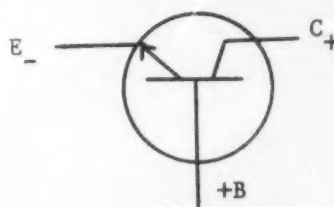
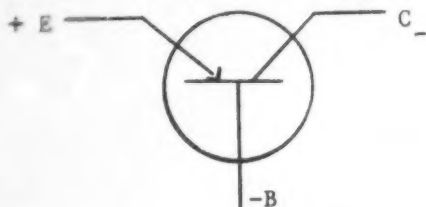
1. What are the three sections of a transistor?

a. EMITTER

b. BASE

c. COLLECTOR

2. Draw a symbol of: a. PNP b. MPN



3. What is the purpose of a heat sink in a power transistor? IT

ACCEPTS AND RADIATES THE HEAT FROM THE TRANSISTOR.

4. The middle letter of the transistor indicates the COLLECTOR polarity.

5. What are three advantages of the transistor over the vacuum tube?

a. SUPERIOR STABILITY

b. GREATER LINEARITY

c. READILY FOLLOWS RAPID VARIATIONS IN LIGHT INTENSITY

6. What are holes? A HOLE IS THE ABSENCE OF AN ELECTRON IN CRYSTAL LATTICE NEUTRALS OF THE INTERIOR OF THE TRANSISTOR

In which type of transistors are holes the majority current carriers?

"P" TYPE

Why? CURRENT FLOW IN PNP

TRANSISTOR IS ACCOMPLISHED BY MOVEMENT OF HOLES THROUGH THE "P" TYPE MATERIAL.

7. What portion of a zener-diode characteristic is most useful for voltage regulator application? THE ZENER REGION
Why? _____
8. Will a semiconductor diode permit current to flow when it is
(a) forward-biased or (b) reversed-biased? (A) FORWARD-BIASED
9. How would you identify the anode of an unmarked diode? BY USING AN OHMMETER WITH LEADS IDENTIFIED ACCORDING TO POLARITY OF BATTERY. WHEN THE NEGATIVE LEAD IS CONNECTED TO THE CATHODE AND THE POSITIVE LEAD CONNECTED TO THE ANODE, THE DIODE WILL BE FORWARD BIASED AND A LOW RESISTANCE READING IS INDICATED. WHEN THE LEADS ARE REVERSED, THE PLUS OR POSITIVE LEAD TO CATHODE AND THE NEGATIVE LEAD TO ANODE, IT WILL BE REVERSED BIASED AND A HIGH REVERSE RESISTANCE READING WILL RESULT.

10. What is a logic circuit? IT IS A CIRCUIT WHICH MAKES DECISIONS OR COMPARISONS.

11. Identify the two states of a logic circuit.
- a. IN THE CASE OF A SWITCH, ON OR OFF.
- b. IN AN ELECTRONIC CIRCUIT, UP OR DOWN, OR (+ OR -)

BASIC THEORY OF ELECTRONICS

DESIRED RESULTS:

To acquaint the apprentice with the basic theory of electronics from the standpoint of industrial control circuits.

INTRODUCTION:

We think of electricity as the flow of electrons in or on a conductor or through a gas or space as in a vacuum tube. We think of electronics as a science which deals with the use, characteristics, and properties of electrons, especially in vacuum tubes. Practical electronics deals with the electron tube itself, with its ability to amplify, rectify, and detect, as well as with the components and circuitry associated with it.

The industrial applications of electronics include timing circuits, photoelectric counting and measuring, theater light dimming, motor control, resistance and arc welding, and many others.

Daily we come in contact with common place electronic equipment which use vacuum tubes, such as: radio, sound motion pictures, record players, public address systems, television, and electric eye door openers. The above equipment also makes use of various types of D C and A C circuits, meters, transformers, capacitors, resistors and other components studied in basic electricity.

The apprentice will probably have his greatest contact with industrial electronics on the job in the form of controls and instrumentation. The equipment used in this field will consist of a power supply, an amplifier, some form of sensing device, and an output device. In working with these devices, it is difficult to distinguish between electricity and electronics.

PRESENTING THE LESSON:

1. Demonstrate the three basic electronic circuits:
 - a. Rectifier circuits
 - b. Amplifier circuits
 - c. Oscillator circuits
2. Explain the use of six types of parts in the circuits:

a. Resistors	d. Transformer
b. Capacitors	e. Switch
c. Induction coil	f. Vacuum tubes

3. Show how a diode tube works:
 - a. Using drawings, show the electron emission from the cathode.
 - b. Demonstrate the diode D C circuit with current flow.
 - c. Show the effect of plate voltage on current flow.
 - d. Show saturation in the diode tube.
 - e. Demonstrate the diode A C circuit with current flow (rectification).
 - f. What is a half wave rectifier circuit?
 - g. What is a full wave rectifier circuit?
4. Show the film if available and note the following points:
 - a. The electron flow within the tube
 - b. The difference in current flow for A C and D C circuits

APPLICATION:

- . Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

BASIC THEORY OF ELECTRONICS

1. The electrician thinks of current in terms of amperes and considers one or two amperes as a very low current. In electronics, we deal with current in milliamperes, and consider one or two amperes to be a very high current.

2. The electrician considers A-C voltage at the consumer location as 110, 220, or 440 volts. In electronics, voltage is generally D-C and often ranges from 300 to 1,000 volts. In this study, we will learn to deal with composite voltages, there will be voltages made up of both D-C and A-C components.

3. We think of power being measured in watts or kilowatts. In electronics, most power requirements are very small, such as milliwatts (1/1000).

The three statements above do not change the basic laws of electricity, but require us to apply the things we know to new situations. Other than the semi-conductor field of electronics, there are only six components commonly used. All six of these components have been studied and now you must apply their use to vacuum tubes.

SWITCHES:

Mechanical devices for completing, interrupting, or changing the connections in an electric circuit.

CIRCUIT:

The electrician works with many types of circuits or paths over which an electric current flows, such as lighting, motor control, etc. There are unlimited variations of the lighting circuit, and there are unlimited variations of the electronic circuits, such as the amplifier circuits. The student that masters the basic circuit will have no real problem with the variations.

COILS:

You are familiar with coils used in motor starters. There is no difference in those coils and the coils used in electronics, except the physical design.

RESISTORS:

A resistor has a power-handling rating from one hundred to several thousand watts. The demands of the circuit in which they are used determines the size. Electronic resistors are specified in ohms or megohms or 1/2 watt or less to 100 watts. The demands of the circuit will determine the size and resistance requirements.

CAPACITORS:

In studying motors, you found that capacitors were used in starting motors and for power factor correction.

Electronic capacitors in radio circuits are used to block the flow of direct current while allowing alternating and pulsating currents to pass. They are rated in microfarads and micro-microfarads.

TRANSFORMERS:

We think of a transformer as a device that transfers electrical energy by electromagnetic induction from one or more circuits to one or more other circuits. It is measured in high voltage and reduces this voltage to usable voltage.

The transformers used in electronics are generally built for specific jobs handling low power at radio frequency. The principles of the large transformer apply to the radio and other electronic devices.

Now, let us consider the new component introduced in this lesson, the vacuum tube. This device involves some new concepts of electricity which you must learn. In use, it acts like either a variable resistor or a switch, or both, depending upon the circuit in which it is used. The main advantage of the vacuum tube is the speed with which it can vary its resistance and turn on or off in response to external signals.

You have learned the theory of electron flow in metallic conductors used in electrical work. It was the flow of free electrons from a negative potential to a positive potential through a conductor that contains free electrons.

Now, let us consider the flow of free electrons through a vacuum or gas. The electron flow is caused by the attraction of unlike charges and the repulsion of like charges. Remember that the flow of current in a vacuum is very small as compared to the flow through a metallic conductor under the same potential. When the proper gas is added to a tube the current flow is increased by a process known as ionization. This will create completely different characteristics for specified uses.

The semi-conductors offer some new concepts in electricity which we must accept and apply in order to understand their use. Semi-conductors are a class of solid materials with high resistance qualities. Another group, more important in communications, are semimetallic elements or oxides in which conductivity is electronic. Semi-conductors are used as rectifiers, detectors, and amplifiers in transistors and thermoelectric elements.

The apprentice will contact industrial electronics on the job in the form of controls and instrumentation. The equipment used in this field will consist of a power supply, an amplifier, and some form of sensing device, and an output device. In working with these devices, it will be difficult to distinguish between electricity and electronics.

NAME _____

LESSON D-24

DATE _____

WORKSHEET

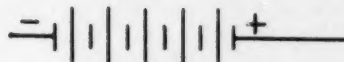
BASIC THEORY OF ELECTRONICS

1. Draw symbols for the following components:

a. Resistor



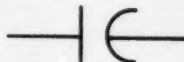
b. Battery



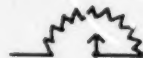
c. N O Relay Contact



d. Capacitor



e. Potentiometer



2. Three basic parts of an electron tube are:

a. ENVELOPE

b. CATHODE

c. ANODE OR PLATE

3. List seven principal functions performed by electron tubes.

a. RECTIFICATION

e. SWITCHES

b. AMPLIFICATION

f. OSCILLATORS

c. RELAYS

g. MODULATION

d. DETECTION

4. Will a vacuum tube diode permit current to flow in both directions?

NO Explain. ONLY THE HEATED ELEMENT (CATHODE) WILL EMIT
ELECTRONS. IF THE NEGATIVE LEAD OF A POWER SUPPLY IS CONNECTED
TO THE PLATE, THE PLATE WILL REPEL THE ELECTRONS EMITTED BY THE
CATHODE AND THERE WILL BE NO CURRENT FLOW.

5. What is meant by the μ of a triode? AMPLIFICATION FACTOR
6. How does a positive limiter differ from a negative limiter?
IN A POSITIVE LIMITER, THE POSITIVE ALTERNATION IS NOT PERMITTED TO BE DEVELOPED IN THE OUTPUT. IN THE NEGATIVE LIMITER, THE NEGATIVE ALTERNATION IS NOT PERMITTED TO PASS.
7. How does a series limiter differ from a parallel limiter?
A SERIES LIMITER HAS ITS OUTPUT IN SERIES WITH THE DIODE.
A PARALLEL LIMITER HAS ITS OUTPUT PARALLEL WITH THE DIODE.
8. What is the purpose of a voltage doubler in reference to rectification? IT PRODUCES BOTH THE NEGATIVE AND POSITIVE HALVES OF THE CYCLE OF DC.
9. Why must a device using a power transformer never be plugged into direct current? BECAUSE THE LOW RESISTANCE OF THE WINDING WILL PERMIT A HIGH DC CURRENT TO FLOW, DESTROYING THE PRIMARY WINDING OF THE TRANSFORMER.
10. In a transformer power supply, what is the purpose of a choke input filter? IMPROVED FILTERING AND IMPROVED REGULATION
11. What is meant by rectification? CHARGING AN ALTERNATING CURRENT WAVE FORM TO AN UNIDIRECTIONAL CURRENT WAVE FORM.
12. Describe the nature of the output voltage of (a) Half-wave rectifier: WAVE FORM IN DURATION OF 180° WITH A SPACE OF 180° BETWEEN WAVE FORMS. (b) Full-wave rectifier WAVE FORMS IN DURATION OF 180° AND ONE BREAK BETWEEN.
13. Is it possible for a tube or CRT to check "good" on a tester and yet be inoperative in a circuit? YES Explain. A TESTER CANNOT DUPLICATE A CIRCUIT CONDITION EXACTLY. ELEMENT VOLTAGE AND LOADING. IN CRT THE TESTER SUPPLIES A MUCH LOWER ANODE VOLTAGE THAN THE TUBE ENCOUNTERS IN THE CIRCUIT.

WELDERS, RESISTORS & RECTIFIERS

DESIRED RESULTS:

1. To study the electric welding processes, how welders can be controlled by electronics, and code requirements for electric welding equipment connected to an electric power supply.
2. To learn the function of resistors and rectifiers in control circuits.

INTRODUCTION:

This Article covers electric arc welding, resistance welding apparatus, and other similar welding equipment that is connected to an electrical supply system.

It is the intent of this Article to amplify or modify parts of the Code in order to properly cover the operating conditions to which electric welder installations are subjected. Accordingly, the appropriate provisions of Chapters 1 through 4 inclusive apply to component parts of electric welder installations except as otherwise provided in this Article.

The control of resistance welders by electronic methods is one of the oldest and most common applications of electronics to the industrial world. Review with the students the basic circuits studied earlier and welding equipment that is connected to an electrical supply according to the Code. The circuits used in the welder are special adaptations of the basic circuits.

When resistance welding takes place, high currents of electricity are caused to flow through two pieces of metal. These pieces of metal are held together under pressure by welding electrodes which are chosen for high electrical and thermal conductivity. A standard electrode material is copper. The disadvantage of using copper is that the electrode tip becomes deformed rapidly. When higher pressure and temperatures are necessary, a hard copper alloy is used. Most machines use circulating water to cool the electrodes. Thus, they select the electrode made of materials containing high electrical and thermal conductivity. This method keeps the temperature low and prevents the electrodes from being welded to the material.

PRESENTING THE LESSON:

1. Discuss the capacity of supply conductors and overcurrent protection for individual welders.
2. Review the general types of welders to be installed and their varying operations.
3. What disconnecting means shall be provided for each welder?
4. What information shall be provided on a nameplate?
5. What are the factors that determine the amount of heat produced by a given welding current?
6. What is the range of voltage generally applied to a weld in resistance welding?
7. What keeps the electrodes from being welded to the material being welded?
8. What is spot welding? Name other classes of welding.
9. List the four steps that are timed or controlled by electronic controls on a resistance welder.
10. In the diagram shown in Figure 8-5, list four components that determine the welding time. What function does each part play?
11. Discuss the use of synchronous control over non-synchronous control.
12. Refer to Figure 8-9 electrostatic welding system. How is the weld produced?
13. Refer to Figure 8-10 magnetic inductor storage welding system. How is the voltage produced for the weld?
14. In Figure 8-11, discuss the basic arc welding control circuit. What determines how quickly or slowly the welding electrode is to be moved toward the work?
15. Discuss the use of resistors and rectifiers in control circuits.

APPLICATION:

Have the students complete the Assignment Questions for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the papers to the students for correction and placing in their workbooks.

NAME _____

LESSON D-25

DATE _____

WORKSHEET

WELDERS, RESISTORS & RECTIFIERS

1. ARC welding and RESISTANCE welding are the two general types of electric welding.
2. In ARC welding, an ARC is drawn between the metal parts to be joined together and a metal electrode, and metal from the electrode is deposited on the joint.
3. In RESISTANCE welding, the metal parts to be joined are passed tightly together between two electrodes, and a TIMED CURRENT is passed through the electrodes and the metal parts to be welded.
4. The maximum overcurrent protection for an electric arc welder is 200 percent of the rated PRIMARY current.
5. A DISCONNECTING MEANS shall be provided in the supply line to each welder.
6. The minimum capacity of a supply conductor to a varying operation type manual-operated resistance welder shall be 50 percent of the rated PRIMARY current, 70 percent for automatic resistance welders.
7. Maximum overcurrent protection for supply conductors to an arc welder shall be 200 percent of PRIMARY rating.
8. The maximum overcurrent protection for a resistance welder shall be 300 percent of the rated PRIMARY current.
9. The maximum overcurrent protection for supply conductors to a resistance welder shall be 300 percent of CONDUCTOR rating.
10. Insulated conductors used for resistor connections shall have a rating of not less than 90 °C (194 °F).
11. Give five reasons why silicon rectifiers are replacing other types of power conversion apparatus:
 - a. HIGHER EFFICIENCY
 - b. MEDIUM COSTS
 - c. LOWER INSTALLATION COSTS
 - d. HIGHER RELIABILITY
 - e. LONGER LIFE

12. Name three other methods of power conversion apparatus:
- a. MOTOR GENERATOR SETS
 - b. ROTARY CONVERTERS
 - c. MERCURY-ARC RECTIFIERS
13. Selenium rectifiers have the unusual ability to HEAL or RESEAL ruptures caused by overvoltages within their ratings.
14. Sometimes a selenium rectifier is used as SURGE protection for SILICON rectifier cells.

LESSON PLAN OUTLINE

TOPICS: Job Management

DESIRED RESULTS:

1. To explain the roles of job management if and when one is promoted.
2. To develop leadership qualities and discuss how the new manager adjusts to his job.
3. To give the students experience in planning, conducting, and evaluating a class on conference session.
4. To teach the "art of listening" for those not engaged in presenting materials.

REFERENCES: All available materials on the subject.

SUGGESTION: That one session be devoted to help plan the lessons with the students and two sessions for presentation and evaluation. See lesson D-27 for possible material to use on "Effective Foremanship".

INTRODUCTION:

The instructor should introduce and help plan the sessions several weeks before the scheduled meetings. The students should do research on the subject and meet with a committee to plan the sessions.

PRESENTING THE LESSON:

The committee should choose the type of presentation, such as role playing, case study, or circular discussion.

The printed outline of an Instructor's Lesson Plan, along with the Information Sheets, should help in planning the sessions.

1. Review the Job Management Sheets from the student outlines.
2. Point out that the following leadership qualities will be developed by participating in these sessions:
 - a. Ability to express oneself
 - b. Analyze and solve daily work problems
 - c. Analytical attitude toward all problems

CLASS DISCUSSION

JOB MANAGEMENT

DISCUSSION OUTLINE:

1. What you manage
 - a. Yourself
 - b. Your helper
 - c. Tools and equipment
 - d. Time and material
2. How you manage--"Bull-of-the-woods," phasing out--replaced by
 - a. Leader
 - b. Instructor
 - c. Paper-work man
3. Why you manage
 - a. Every job must have some management
 - b. Increase efficiency
 - c. Lower costs
 - d. Improve profit margin
4. When you manage
 - a. Before job starts
 - b. During job
 - c. After completion of job
 - d. "Off duty" hours--planning and layout
5. Where you manage
 - a. On the job
 - b. Personal life
 - c. Community life

FOLLOW THESE TWELVE RULES IF YOU'RE PROMOTED
TO A MANAGEMENT JOB

(A. J. Drucker, Manager of the Management Development Center in IBM's Data Processing Division suggests:)

1. Don't get personally involved when something doesn't seem to be turning out right. (Help your subordinates find a solution.)
2. Talk less and listen more.
3. Make sure your door is open to your associates. You can't learn everything from written reports.
4. Remember that what motivated you may not motivate your subordinates. (Find out what makes each man tick and apply it accordingly.)
5. Set out to help your men develop their greatest potential. (You also will be judged on how well you perform this job.)
6. Adopt a positive attitude in performing the administrative detail your job requires. (How well you handle it will figure importantly in any estimate of your future potential.)
7. Don't shy away from decisions in the early months. Your judgments must have been good so far or you wouldn't have been promoted. (So don't be afraid of making them.)
8. Think management. You are the company; its policies are your policies. (So don't apologize for any headquarters action. If you do, you will weaken your authority.)
9. Don't always support the old and familiar. (Give a fair hearing to new ideas.)
10. Gradually moderate your former close relationships with subordinates.
11. Don't tolerate mediocrity. (Your subordinates want to meet a high standard.)
12. Work harder than ever.

MANAGEMENT SHOULD
ELIMINATE COMPLAINTS ABOUT CONFERENCES

According to research on business meetings conducted by a manufacturer, the corporate officer or supervisor errs in one or more of three ways:

1. He calls a meeting without any real reason. The subject could have just as easily been resolved by a telephone call.
2. He calls a meeting at the drop of a hat. (Nobody has a chance to prepare, gather facts, or do any advanced thinking and nothing is achieved.)
3. He may not conduct the meeting well; it gets underway late, is interrupted by telephone calls and secretaries, and discussions become untracked resulting in no decisions.

You'll do better following these simple tips:

1. Never call a meeting if you can write or phone - or either delegate the job or do it yourself.
2. Invite only those persons who are directly concerned with the matter at hand.
3. Always tell them ahead of time what topics will be covered and give them time to prepare.
4. Start on time, end on time, and don't permit any interruptions.

SUPPLEMENTARY REFERENCES

"Here's How" Booklets: (Available from the Bureau of National Affairs, Incorporated, 1231 24th Street, N.W., Washington, D. C., 20037. The cost of each booklet is 25¢.)

How to Be a Leader, A 10-point program to develop and demonstrate leadership.

How to Get Teamwork, Ten steps to high employee morale and a strong team spirit.

How to Correct Misunderstandings About Management, How to get facts across to employees, scotch gossip, rumor, and hearsay.

LESSON PLAN OUTLINE

TOPICS: Effective Foremanship

DESIRED RESULTS:

1. To convey the varied functions and job qualities needed to be a good foreman.
2. To develop these qualities as our own and apply them in our work.
3. To help the students set up a group discussion of what a good foreman is.
4. To instill a desire for the men to become tomorrow's leaders.

REFERENCES: All available materials on the subject.

SUGGESTION: That one session be devoted to help plan the lessons with the students and two sessions for presentation and evaluation.

INTRODUCTION:

The instructor should introduce and help plan the sessions several weeks before the scheduled meetings. The students should do research on the subject and meet with a committee to plan the sessions.

PRESENTING THE LESSON:

The committee should choose the type of presentation, such as role playing, case study, or circular discussion.

The printed outline of an Instructor's Lesson Plan, along with the Information Sheets, should help in planning the sessions.

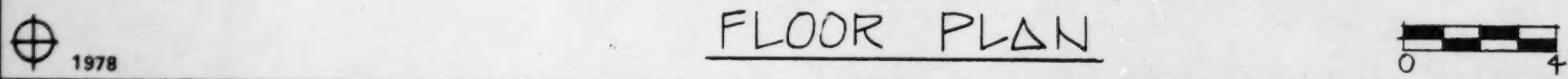
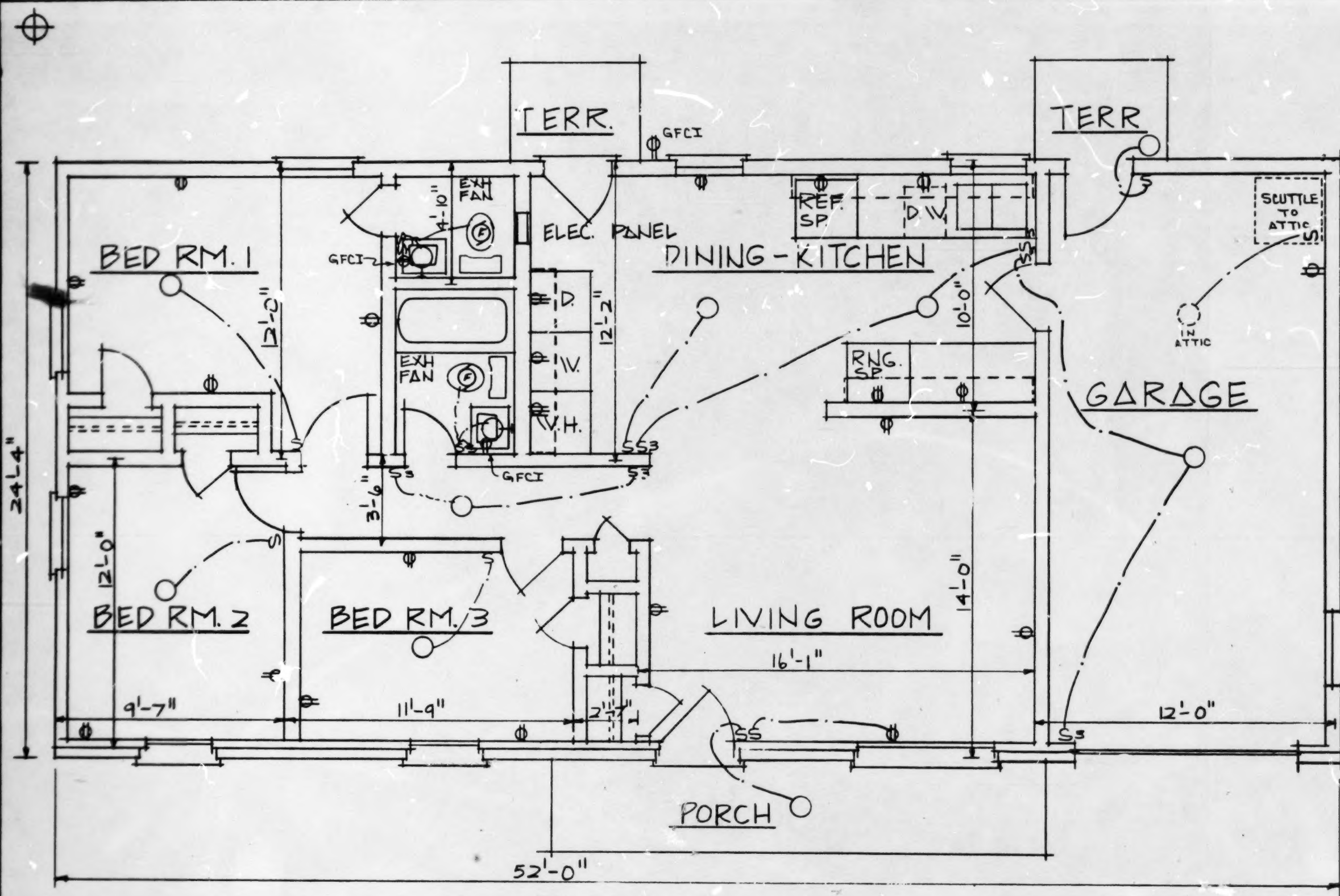
1. Review the Effective Foremanship from the student outlines.
2. Point out that the following leadership qualities will be developed by participating in these sessions:
 - a. Ability to express oneself
 - b. Analyze and solve daily work problems
 - c. Analytical attitude toward all problems

CLASS DISCUSSION:

EFFECTIVE FOREMANSHIP

DISCUSSION OUTLINE:

1. Where foremen come from
2. Why are they selected
 - a. Leadership qualities
 - b. Organizational ability
 - c. Mechanical skill
 - d. Technical skill
 - e. Judgment
 - f. Initiative
 - g. Education
 - h. Character
 - i. Human interest
 - j. Physical and mental ability
3. Foreman's training
 - a. Starts at childhood
 - b. Develops as he grows
 - c. Improves as he progresses
 - d. Always something new to learn
 - e. No "guaranteed course" with all the answers
4. Half of the job almost done
 - a. Apprentice training
 - (1) On-the-job
 - (2) Related technical training
 - b. Your education in general
 - c. Your life's experiences
 - d. Your association with other people
5. The other half of the job
 - a. Skills of leadership
 - b. Methods of personnel supervision
 - c. Development of sound administrative procedures
 - d. Improving on-the-job performance



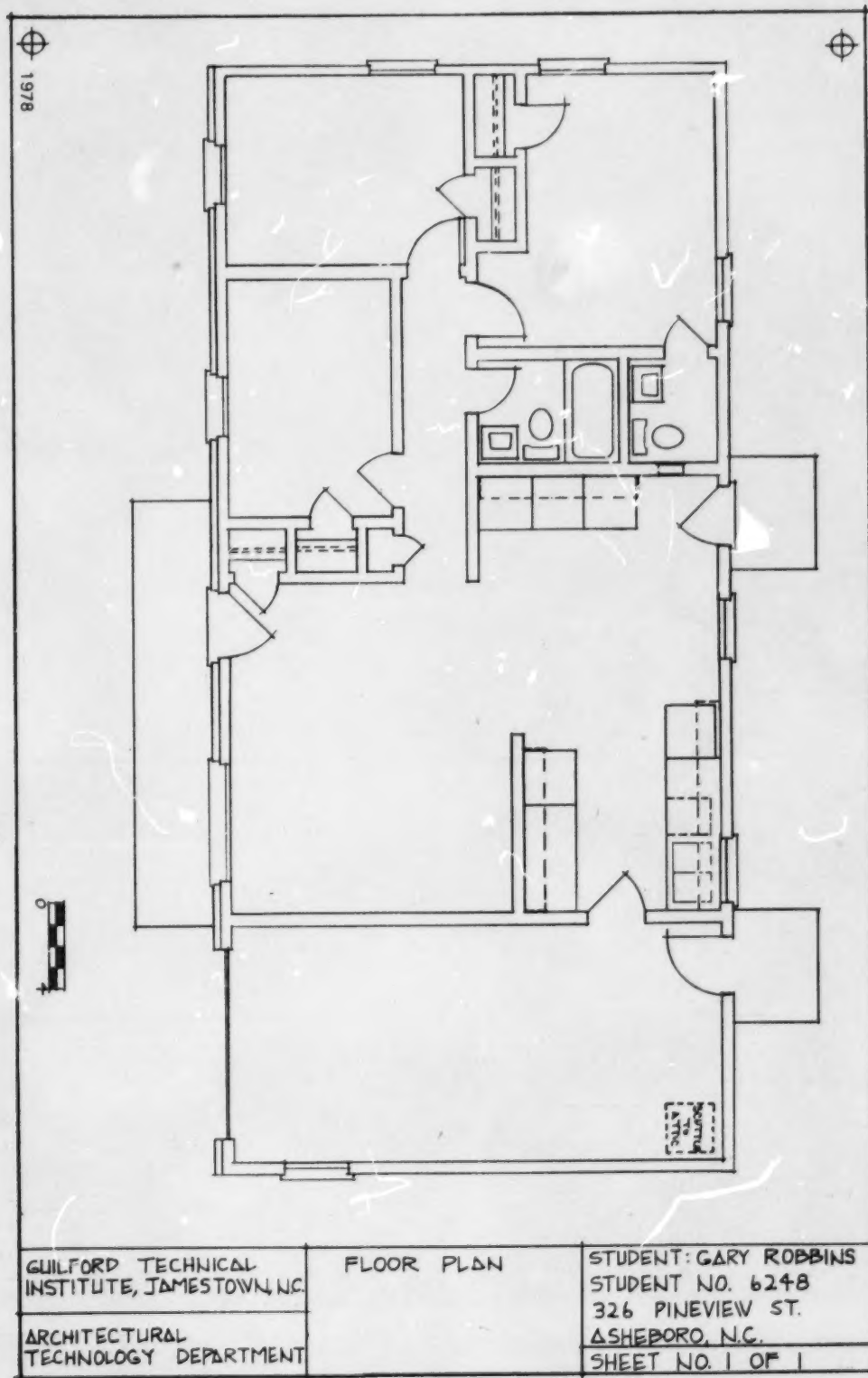
FLOOR PLAN

STUDENT: GARY ROBBINS
 STUDENT NO. 6248
 326 PINEVIEW ST
 ASHEBORO, N.C.

FLOOR PLAN

GUILFORD TECHNICAL
 INSTITUTE, JAMESTOWN NC
 ARCHITECTURAL
 TECHNOLOGY DEPARTMENT

SHEET NO. 1 OF 1





TERR.

TERR.

BED RM. 1

EXH
FAN

ELEC PANEL

REF.
SP.

D
W

DINING-KITCHEN

D

EXH
FAN

W

RNG.
SP.

GARAGE

WH

BED RM. 2

BED RM. 3

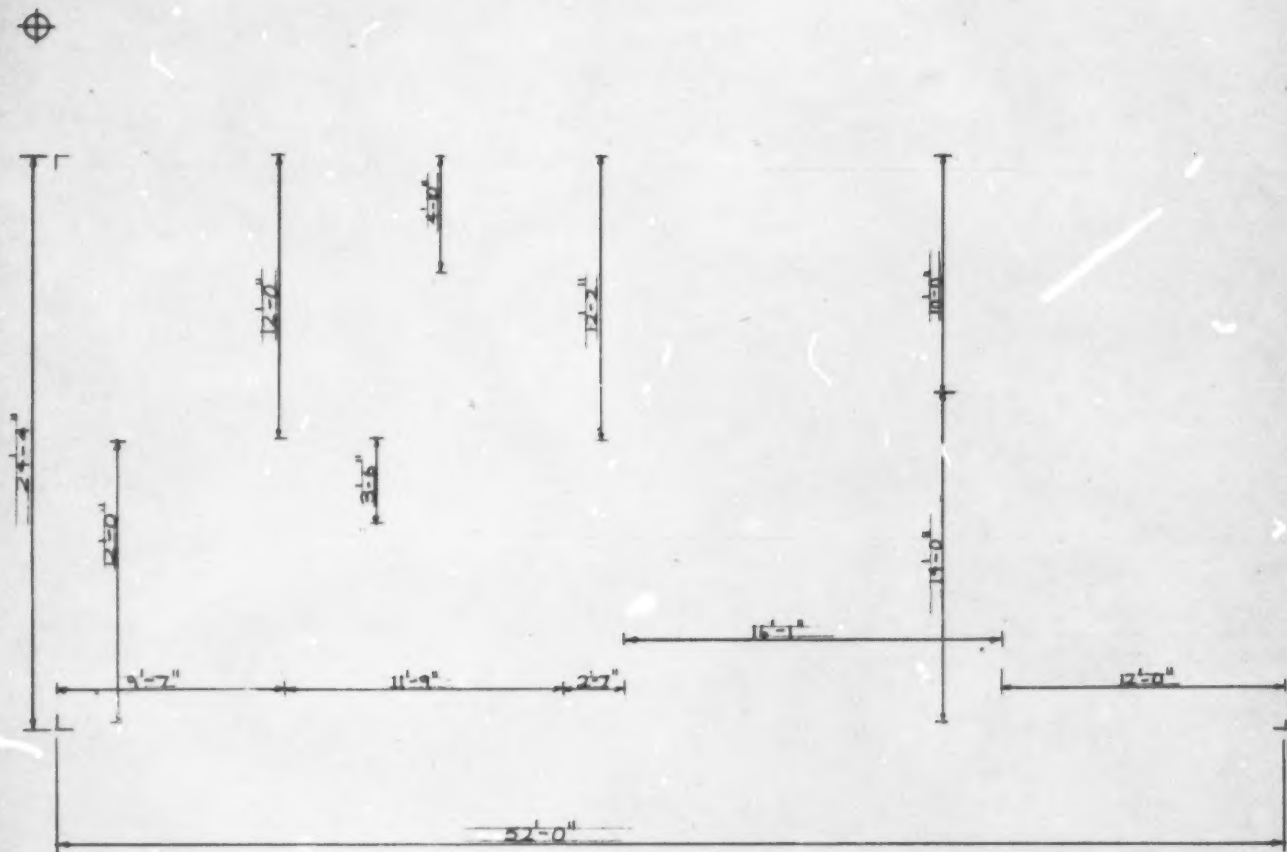
LIVING ROOM

PORCH



1978

120





1978

122



1978

8500 KW BASE BOARD HEAT
OR
(9400 KW CEILING CABLE HEAT)



20000 BTU
PAD CONDENSER

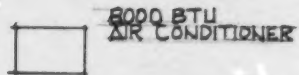


10 KW ELECTRIC FURNACE
IN ATTIC SPACE

10 KW ELECTRIC FURNACE
WITH AIR CONDITIONER



1978



~~8000 BTU~~
~~AIR CONDITIONER~~



~~15000 BTU~~
~~AIR CONDITIONER~~



1978

~~WINDOW AIR CONDITIONERS~~
~~2300 BTU~~

APPENDIX

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-1 THRU D-5
TEST D-1

1. Cable trays shall be installed as a complete SUPPORT system.
2. Each run of cable tray shall be complete before the INSTALLATION of cables.
3. List three types of cables that may be used in cable trays.
 - (a) MI CABLE
 - (b) METAL-CLAD CABLE
 - (c) NON-METALLIC SHIELDED AND SHEATHED CABLE
 - (d) POWERS CONTROL TRAY CABLE
 - (e) MULTI-CONDUCTOR UNDERGROUND FEEDER & BRANCH CIRCUIT BRANCH
 - (f) MULTI-CONDUCTOR SERVICE ENTRANCE CABLE D-F OR ALTERNATE ANSWERS
4. A cable tray system shall not be used as a grounded circuit conductor, True/False TRUE Code Reference 318-5.
5. Are single conductor cables allowed to be installed in cable trays? YES Code Reference 318-7(d) OR 318 2(B) 1 & 2.
6. If the answer to question #5, is yes, Give the minimum size conductor Permitted. 250 MCM.
7. Trays shall be CONTINUOUS and MECHANICALLY connected to the enclosure in which cables terminate.
8. Nonmetallic extensions shall be made from a 15 or 20 ampere branch circuit.
9. Nonmetallic extensions may be installed in a residence or OFFICE.
10. An extension shall be attached only to woodwork or PLASTER.
11. Each run of nonmetallic extensions shall terminate in a fitting which covers the END of the assembly.
12. Fastenings shall be located a MAXIMUM of eight inches on centers.
13. Receptacle type tap connector shall be of the LOCKING type.
14. An underplaster extension may be used only for extending an existing BRANCH circuit.

NAME _____

TEST D-1

15. An underplaster extension may be installed in a FIRE - RESISTIVE constructed building only.
16. NM cable may be used for underplaster extension. True/False
FALSE Code Reference 344-2
17. Underplaster extensions shall not extend beyond the FLOOR it originates unless it is installed in RIGID metal CONDUIT, AC metal clad cable, or M I cable.
18. Underplaster extensions shall be mounted on the face of MASONRY walls.
19. The conductors, including splices and taps, shall not fill the raceway to more than 75 percent of its area at that point.
20. All splices and taps shall be made by APPROVED methods.
21. The maximum voltage normally permitted in a surface metal raceway is 300 volts.
22. No conductor LARGER than that for which the raceway is designed shall be installed in surface metal raceway.
23. Surface metal raceways may extend through WALLS and FLOORS.
24. Raceways shall be CONTINUOUS from outlet to outlet.
25. Combination raceways shall have SEPARATE compartments for signal, lighting, and power circuits.
26. Metal multioutlet assembly may be extended through DRY partitions.
27. Assembly may be installed in (A) DRY location(s).
(a) dry (b) wet (c) both
28. Assembly is a raceway designed to hold CONDUCTORS and RECEPTACLES.
29. Assembly may be FIELD or FACTORY assembled.
30. Receptacles in a multioutlet assembly shall be THREE -wire, GROUNDING type.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-6 THRU D-10
TEST D-2

1. Dead ends of raceways shall be (A) CLOSED.
(a) closed (b) left open for future use.
2. The combined cross-sectional area of all conductors shall not exceed (A) 40 percent of the interior area of the raceway except that when raceway contains only type AC or NM sheathed cable.
(a) 40 (b) 50 (c) 60
3. Junction boxes used with metal raceways shall be (A) METAL.
(a) metal (b) plastic (c) wood
4. Splices and taps shall be made only in JUNCTION BOXES.
5. Conductors supplying a discontinued outlet shall be removed from the UNDERFLOOR RACEWAY.
6. Underfloor raceways in office buildings may be used for low voltage POWER, TELEPHONE and SIGNAL systems.
7. The maximum voltage permitted in a raceway is 600 volts..
8. Wires for TELEPHONE or SIGNAL systems shall not be run in the same duct with convenience outlet wires.
9. No conductor larger than # 1/0 shall be installed in any cell or header except by special permission.
10. Inserts shall be ELECTRICALLY continuous with the raceway.
11. Splices and taps shall be made only in header access units or JUNCTION BOXES.
12. Conductors feeding a discontinued outlet shall be REMOVED from the raceway.
13. So called loop wiring is not considered to be a splice or tap in cellular metal floor raceway. True/False TRUE Code Reference 356-6
14. Headers permit the installation of electrical CONDUCTORS from a distribution center to the cells.
15. Core DRILLS are used to cut hole in center of cell.

NAME _____

TEST D-2

16. In general, the cells of a cellular metal floor are on SIX inch centers.
17. No conductor larger than # 1/0 shall be installed, except by special permission.
18. Connections to cabinets and extensions from cells to outlets shall be made by means of RIGID or FLEXIBLE conduit or approved fittings.
19. Headers is a metal raceway providing access to predetermined CELLS in the slab.
20. Header duct shall be ELECTRICALLY continuous through the system and shall be ELECTRICALLY bonded to the enclosure of the DISTRIBUTION SYSTEM.
21. Connections between cabinet and header shall be made by means of METALLIC DUCT and APPROVED FITTINGS.
22. A GROUNDING conductor shall connect the receptacle to a positive ground connection on the HEADER duct.
23. Busway shall be installed only for EXPOSED work.
24. Busways may be installed as service ENTRANCE conductors.
25. Busways may extend through floors provided a totally ENCLOSED busway is installed up to a minimum of 6 feet above the floor for physical PROTECTION.
26. Branch circuits from busways shall be provided with PLUG - in devices.
27. Busway taps, having a minimum rating of 1/3 the ampere capacity of main duct protective devices and a maximum length of 50 feet, are not required to have OVERCURRENT protective devices.
28. Rating of the overcurrent PROTECTIVE device determines the ampere rating of the busway branch circuit.
29. Plug-in bus duct overcurrent protective devices are either:
 - (a) FUSIBLE UNITS
 - (b) CIRCUIT BREAKER UNITS

NAME _____

TEST D-2

30. One-bolt construction of modern bus duct systems require TORQUE wrenches to assure proper joint connection.
31. Busways are normally hung by what three methods?
- (a) ROD HANGERS
(b) CHAIN HANGERS
(c) TRAPESE HANGERS
- ALTERNATE ANSWER:
MESSENGER CABLE SUPPORTS
32. Cablebus is an approved assembly of INSULATED conductors mounted in SPACED relationship in a ventilated METAL protective SUPPORTING structure.
33. The minimum wire size for cablebus conductors is # 1/0 AWG..
34. The conductor insulation for cablebus conductors is 75 °C. The code designation for the insulation is XHHW.
35. The ampacity of the cablebus conductor is based on single conductors in FREE AIR, as found in tables 310-17 and 310-19 of the N. E. Code.
36. Cablebus voltage ratings are from zero volts to 35000 volts.
37. The supporting structure of cablebus can be used on an equipment GROUNDING conductor when adequately bonded.
38. Special fittings are required for the cablebus system:
- (a) HORIZONTAL AND VERTICAL CHANGES IN DIRECTION
(b) DEAD ENDS
(c) TERMINATIONS AND CONNECTIONS AT EQUIPMENT

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-11 THRU D-14
TEST D-3

1. Switches shall not disconnect the GROUND CONDUCTOR of a circuit.
2. Switches shall be mounted in METAL BOXES and shall be EXTERNALLY operated.
3. Single-throw knife switch shall be connected so that blades are DOWN or DEAD when the switch is open.
4. Voltage between ganged snap switches cannot exceed 300 volts unless permanently installed BARRIERS are installed between adjacent switches.
5. Circuit breakers or switches of special design shall be installed to INTERRUPT circuits greater than 1200 amperes at 250 volts or less.
6. Isolating switches are installed to ISOLATE the circuit from the SOURCE and are intended to be operated only after the circuit has been OPENED.
7. What two items of information appear on all switches?
(a) CURRENT RATING IN AMPERES
(b) VOLTAGE RATING
ALTERNATE ANSWER: HORSEPOWER RATING IF DESIGNED FOR PURPOSE
8. PANELBOARDS shall be accessible only from the front.
9. Switchboards are generally accessible from the FRONT and REAR.
10. There shall be a 3 foot minimum clearance above a switchboard in a room having a non-fireproof ceiling.
11. Define a lighting panelboard: HAS MORE THAN 10% OF ITS OVERCURRENT DEVICES RATED 30 AMPERES OR LESS FOR WHICH NEUTRAL CONNECTIONS ARE PROVIDED.
12. There shall be a maximum of 42 overcurrent devices in a lighting panelboard.
13. Maximum overcurrent protection of a lighting panelboard shall be 200 amperes.

NAME _____

TEST D-3

14. The total continuous load on an overcurrent protective device in a panelboard shall not exceed 80 percent of its rating.
15. An equipment grounding terminal bar is required for all panelboards. True/False FALSE Code Reference 384-27
16. The neutral bar can be used as a terminal for equipment grounding conductors. True/False FALSE Code Reference 384-27
17. Where are the equipment grounding and neutral terminal bars bonded together? AT SERVICE ENTRANCE EQUIPMENT ONLY.
18. High voltage equipment and conductors must have INSULATION sufficient for the voltage employed.
19. Where bare connections and buses are used, insulation is provided by SEPARATION. The higher the voltage, the greater the SEPARATION.
20. What are the five main methods of installing above ground high voltage conductors?
- (a) IN RIGID METAL CONDUIT
 - (b) CABLEBUS
 - (c) METAL-CLAD CABLE
 - (d) BARE CONDUCTORS OR BUSES
 - (e) INSULATED WIRES
21. What is the purpose of shielding a high voltage conductor?
- TO CONFINE THE DIELECTRIC FIELD.
22. Is a special type terminator required for metal-sheathed high voltage cable? Yes/No. YES. If so, what type? ONE WHICH WILL PREVENT MOISTURE FROM ENTERING THE INSULATION
23. What is the major difference in the equipment installed in regular work and that of high voltage equipment? ONLY THE DIFFERENCE IN VOLTAGES.
24. What types of public buildings are covered under Article 520?
- | | |
|---------------------------------|-------------------------------|
| (a) <u>DRAMATIC SHOWS</u> | (f) <u>NIGHT CLUBS</u> |
| (b) <u>OPERATIC SHOWS</u> | (g) <u>DANCE HALLS</u> |
| (c) <u>MOTION PICTURE SHOWS</u> | (h) <u>ARMORIES</u> |
| (d) <u>SPORTING ARENAS</u> | (i) <u>BOWLING ALLEYS</u> |
| (e) <u>PUBLIC AUDITORIUMS</u> | (j) <u>TELEVISION STUDIOS</u> |

25. Stage switchboards shall contain OVERCURRENT protection and CONTROL for all stage receptacles.
26. Maximum overcurrent protection for a dimmer shall be 125 percent of the dimmer rating.
27. The circuit supply AUTOTRANSFORMER type dimmers shall not exceed 150 volts between conductors.
28. Minimum rating for arc lamp receptacles shall be 50 amperes; minimum wire size shall be # 6 AWG.
29. Minimum rating for INCANDESCENT lamp receptacles shall be 20 amperes; minimum wire size shall be # 12 AWG.
30. Plugs for ARC and INCANDESCENT receptacles shall not be interchangeable.
31. Pendant lampholders shall not be installed in DRESSING rooms.
32. All LIGHTS and RECEPTACLES in dressing rooms shall be controlled by wall switches.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-15 THRU D-18
TEST D-4

1. What types of communications circuits are covered by Article 800 of the N. E. Code?

(a) TELEPHONE (d) FIRE ALARM
(b) TELEGRAPH (e) BURGLAR ALARM
(c) DISTRICT MESSENGER

2. Circle correct words to make true statements:

These systems (are / are not) connected to a central station and they (do / do not) use similar types of equipment, methods of installation and maintenance.

3. An approved protector shall be installed on each AERIAL or UNDERGROUND circuit.
4. OVERHEAD communications conductors shall be installed BELOW the light and power conductors.
5. Conductors passing over buildings shall be kept a minimum of 8 feet above any roof.
6. Open conductors on buildings shall be separated at least 4 inches from light or power conductors not in CONDUIT or CABLE.
7. Underground conductors in a manhole shall be installed in a SEPARATE SECTION from the light or power conductors.
8. Why should all grounding electrodes be bonded together? TO
LIMIT THE POTENTIAL DIFFERENCE BETWEEN THE GROUNDING ELECTRODE AND THEIR ASSOCIATED WIRING SYSTEMS.
- Give the N. E. Code Article which allows this. 250-86
9. Outdoor antenna conductors shall not cross over LIGHT or POWER conductors.
10. Antenna masts shall be permanently GROUNDING.
11. Minimum distance between open conductors of a communication system on buildings and lighting system conductors shall be at least 6 feet.

NAME _____

TEST D-4

12. The grounding conductor shall be of COPPER.
13. The grounding conductor may be INSULATED or BARE.
14. The grounding conductor shall be connected to a METALLIC
PIPE underground electrode by means of a BOLTED
CLAMP.
15. One receiving station grounding conductor may be used for PROTECTIVE
and OPERATING purposes.
16. Interlocks shall be provided on all TRANSMITTER access doors.
17. Article 645 of the N. E. Code applies to the following items of
data processing systems:
 - (a) POWER SUPPLY WIRING
 - (b) EQUIPMENT
 - (c) EQUIPMENT INTERCONNECTING WIRING
 - (d) GROUNDING
 - (e) DATA COMMUNICATIONS EQUIPMENT
18. The ampacity of the branch circuit conductors supplying data
processing equipment shall be at least 125 percent of the total
CONNECTED LOAD.
19. What are three methods of connecting data processing systems to their
power supply?
 - (a) COMPUTER CABLE
 - (b) FLEXIBLE CORD
 - (c) CORD SET ASSEMBLY
20. Branch circuit supply conductors installed under a raised floor
feeding receptacle shall be installed in:
 - (a) RIGID CONDUIT
 - (b) ELECTRICAL METALLIC TUBING
 - (c) FLEXIBLE METAL CONDUIT
 - (d) TYPE MI CABLE
 - (e) TYPE ALS CABLE OR CS CABLE
21. What two systems must be provided with a disconnecting means readily
accessible within the data processing room?
 - (a) VENTILATION SYSTEM
 - (b) POWER TO ALL ELECTRICAL EQUIPMENT WITHIN ROOM EXCEPT LIGHTING

NAME _____

TEST D-4

22. List the three items of information which must be shown on each item of electrical data processing equipment.

- (a) RATING IN VOLTS
(b) OPERATING FREQUENCY
(c) TOTAL LOAD IN AMPERES

23. Low energy circuits have the POWER limited and are considered Class 2 remote-control circuits.

24. Low voltage power circuits have the CURRENT limited and are considered Class 1 remote-control circuits.

25. Safety control circuits are considered as Class 1 remote-control circuits.

26. Conductor sizes are usually No. 18 or No. 16 AWG.

27. Match the proper voltage with the limiting current for Class II systems.

Column A Voltage

Column B Low Current

- 2 (a) Maximum 15 volts
5 (b) 15 to 30 volts
3 (c) 30 to 60 volts
1 (d) 60 to 150 volts
4 (e) Maximum 150 volts

1. One ampere
2. 5 amperes
3. 1.6 amperes
4. 5 milliamperes
5. 3.2 amperes
6. 15 amperes

28. Maximum line side protection for a Class II remote-control system transformer is 20 amperes.

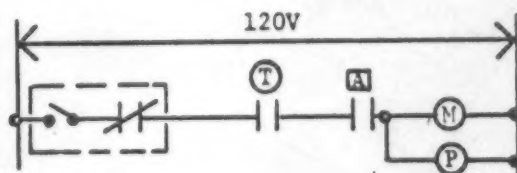
29. Outside installation of Class II remote-control system wiring requires lightning protection. Yes/No YES. Give the N. E. Code section for your answer 725-41 AND 800-2.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-19 THRU D-21
TEST D-5

1. A motor circuit should be converted to a SCHEMATIC DIAGRAM in order to analyze it.
2. In an analysis of a control circuit, always consider the circuit ONE COMPONENT at a time.
3. A repairman should always consider every component of a circuit in its NORMAL and ENERGIZED positions.
4. Be systematic in the study of a circuit contact by CONTACT and coil by COIL.
5. Always study a control circuit through its normal sequence from LEFT to RIGHT.
6. A good troubleshooter has the ability to ANALYZE the control circuit and determine quickly which COMPONENT is causing the malfunction of the equipment.
7. Describe the operation of the following schematic diagram:



8. Maintenance means to MAINTAIN the equipment in OPERATION.
9. Maintenance is to clean it, TIGHTEN it, LUBRICATE, and INSPECT it frequently.
10. Improper LINKAGE adjustment is a frequent cause of coil burn-out on brake solenoids.
11. The greatest causes of control system failures are DUST and DIRT; GREASE and OIL.
12. Short circuits and grounds may be prevented by the proper inspection of insulation and by using a MEGGAR tester.
13. The first law of maintenance is to KNOW YOUR EQUIPMENT.

NAME _____

TEST D-5

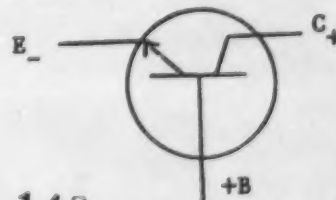
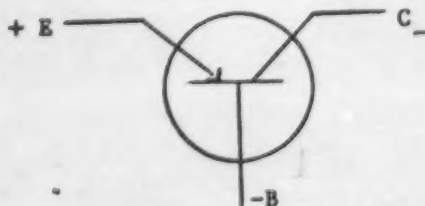
14. The second law of maintenance is to be a good OBSERVER.
15. Motor starter failure is due frequently to CONTACT TROUBLE.
16. Excessive arcing and pitting is caused by improper ALIGNMENT or lack of contact PRESSURE.
17. List two major causes of automatic equipment failure:
(a) IMPROPER ADJUSTMENT OF CONTACTS
(b) TIME-DELAY CIRCUITS
18. List two major causes of coil burnout:
(a) FAILURE OF MAGNET CIRCUIT TO CLOSE
(b) IMPROPER VOLTAGE
19. Time delay relays should be ADJUSTED periodically.
20. Limit switches are prone to MECHANICAL FAILURE.
21. Troubleshooting of control circuits requires an analytical mind trained in all the aspects of control FUNCTIONS, COMPONENTS, CIRCUITS, and circuit ANALYSIS.
22. Efficient troubleshooting is accomplished by EFFICIENT and ACCURATE circuit analysis.
23. The initial step in troubleshooting is to ANALYZE the CIRCUIT.
24. The second step is to follow the operation of the EQUIPMENT through the expected SEQUENCE to find the SECTION of the circuit that is malfunctioning.
25. Control circuits are made up basically of CONTACTS and COILS.
26. A basic rule in troubleshooting is to CHANGE only one thing at a time.
27. A troubleshooter should be equipped with the following testing meters: VOLTMETER, AMMETER, and an OHMMETER.
28. The repairman should change only the CONTROL COMPONENT that is causing the circuit to malfunction.

NAME _____

DATE _____

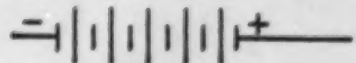
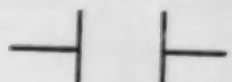
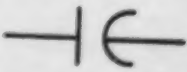
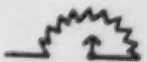
ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-22 THRU D-27
TEST D-6

1. A system of machine control which utilizes no MOVING parts or ELECTRICAL contacts is defined as static control.
2. The life of a control system is increased by the use of SOLID STATE devices.
3. List five elements of logic functions:
 - (a) AND
 - (b) OR
 - (c) NOT OR NOR
 - (d) MEMORY
 - (e) DELAY
4. The subject of "static control" can be broken down into three parts:
 - (a) INFORMATION
 - (b) DECISION OR "BRAINS"
 - (c) ACTION
5. The oldest method of static control uses VACUUM TUBES.
6. The most reliable static control uses MAGNETIC amplifiers in conjunction with rectifiers, CAPACITORS and RESISTORS.
7. The "Information Section" of a machine is called SENSING DEVICES.
8. The "Action Section" operates an AMPLIFIER to produce the desired results.
9. Logic devices may have one or more INPUTS and a single OUTPUT.
10. What are the three sections of a transistor?
 - (a) EMITTER
 - (b) BASE
 - (c) COLLECTOR
11. Draw a symbol of: (a) PNP (b) NPN



NAME _____

TEST D-6

12. The middle letter of the transistor indicates the COLLECTOR polarity.
13. What are three advantages of the transistor over the vacuum tube?
- (a) SUPERIOR STABILITY
 - (b) GREATER LINEARITY
 - (c) READILY FOLLOWS RAPID VARIATIONS IN LIGHT INTENSITY
14. Will a semiconductor diode permit current to flow when it is
(a) forward-biased or (b) reversed-biased? (A) FORWARD-BIASED
15. How would you identify the anode of an unmarked diode? BY USING AN OHMMETER WITH LEADS IDENTIFIED ACCORDING TO POLARITY OF BATTERY. WHEN THE NEGATIVE LEAD IS CONNECTED TO THE CATHODE AND THE POSITIVE LEAD CONNECTED TO THE ANODE, THE DIODE WILL BE FORWARD BIASED AND A LOW RESISTANCE READING IS INDICATED. WHEN THE LEADS ARE REVERSED, THE PLUS OR POSITIVE LEAD TO CATHODE AND THE NEGATIVE LEAD TO ANODE, IT WILL BE REVERSED BIASED AND A HIGH REVERSE RESISTANCE READING WILL RESULT.
16. What is a logic circuit? IT IS A CIRCUIT WHICH MAKES DECISIONS OR COMPARISONS.
17. Draw symbols for the following components:
- (a) Resistor 
 - (b) Battery 
 - (c) N O Relay Contact 
 - (d) Capacitor 
 - (e) Potentiometer 

NAME _____

TEST D-6

18. Three basic parts of an electron tube are:

- (a) ENVELOPE
- (b) CATHODE
- (c) ANODE OR PLATE

19. List seven principal functions performed by electron tubes:

- | | |
|--------------------------|------------------------|
| (a) <u>RECTIFICATION</u> | (e) <u>SWITCHES</u> |
| (b) <u>AMPLIFICATION</u> | (f) <u>OSCILLATORS</u> |
| (c) <u>RELAYS</u> | (g) <u>MODULATION</u> |
| (d) <u>DETECTION</u> | |

20. How does a positive limiter differ from a negative limiter?

IN A POSITIVE LIMITER, THE POSITIVE ALTERNATION IS NOT PERMITTED TO BE DEVELOPED IN THE OUTPUT. IN THE NEGATIVE LIMITER, THE NEGATIVE ALTERNATION IS NOT PERMITTED TO PASS.

21. Why must a device using a power transformer never be plugged into direct current? BECAUSE THE LOW RESISTANCE OF THE WINDING WILL PERMIT A HIGH DC CURRENT TO FLOW, DESTROYING THE PRIMARY WINDING OF THE TRANSFORMER.

22. Describe the nature of the output voltage of (a) half-wave rectifier: WAVE FORM IN DURATION OF 180° WITH A SPACE OF 180° BETWEEN WAVE FORMS. (b) full-wave rectifier WAVE FORMS IN DURATION OF 180° AND ONE BREAK BETWEEN.

23. Is it possible for a tube or CRT to check "good" on a tester and yet be inoperative in a circuit? YES Explain. A TESTER CANNOT DUPLICATE A CIRCUIT CONDITION EXACTLY ELEMENT VOLTAGE AND LOADING. IN CRT THE TESTER SUPPLIES A MUCH LOWER ANODE VOLTAGE THAN THE TUBE ENCOUNTERS IN THE CIRCUIT.

24. ARC welding and RESISTANCE welding are the two general types of electric welding.

25. In ARC welding, an ARC is drawn between the metal parts to be joined together and a metal electrode, and metal from the electrode is deposited on the joint.

26. In RESISTANCE welding, the metal parts to be joined are passed tightly together between two electrodes, and a TIMED CURRENT is passed through the electrodes and the metal parts to be welded.

NAME _____

TEST D-6

27. The maximum overcurrent protection for an electric arc welder is 200 percent of the rated PRIMARY current.
28. The minimum capacity of a supply conductor to a varying operation type manual-operated resistance welder shall be 50 percent of the rated PRIMARY current, 70 percent for automatic resistance welders.
29. Maximum overcurrent protection for supply conductors to an arc welder shall be 200 percent of PRIMARY rating.
30. The maximum overcurrent protection for a resistance welder shall be 300 percent of the rated PRIMARY current.
31. The maximum overcurrent protection for supply conductors to a resistance welder shall be 300 percent of CONDUCTOR rating.
32. Give five reasons why silicon rectifiers are replacing other types of power conversion apparatus:
- | | |
|-------------------------------------|-------------------------------|
| (a) <u>HIGHER EFFICIENCY</u> | (d) <u>HIGHER RELIABILITY</u> |
| (b) <u>MEDIUM COSTS</u> | (e) <u>LONGER LIFE</u> |
| (c) <u>LOWER INSTALLATION COSTS</u> | |
33. Name three other methods of power conversion apparatus:
- | |
|-----------------------------------|
| (a) <u>MOTOR GENERATOR SETS</u> |
| (b) <u>ROTARY CONVERTERS</u> |
| (c) <u>MERCURY-ARC RECTIFIERS</u> |
34. What is the most important item you will ever have to manage?
- FIRST - YOURSELF, SECOND - YOUR TIME, THIRD - YOUR TOOLS, EQUIP-
MENT, AND MATERIAL
35. How is the best way to manage? BY LEADERSHIP AND EXAMPLE
36. Why must every job have some type of management?
- | |
|----------------------------------|
| (a) <u>INCREASE EFFICIENCY</u> |
| (b) <u>LOWER JOB COSTS</u> |
| (c) <u>IMPROVE PROFIT MARGIN</u> |
37. When does job management start? BEFORE THE JOB BEGINS; AS IT
PROGRESSES; AFTER "WORK" IS COMPLETED

NAME _____

TEST D-6

38. List the 5 most important characteristics that make a good foreman.

- (a) _____
- (b) _____
- (c) _____
- (d) _____
- (e) _____

NAME _____
DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-1 THRU D-5
TEST D-1

1. Cable trays shall be installed as a complete _____ system.
2. Each run of cable tray shall be complete before the _____ of cables.
3. List three types of cables that may be used in cable trays.
 - (a) _____
 - (b) _____
 - (c) _____
4. A cable tray system shall not be used as a grounded circuit conductor, True/False _____ Code Reference _____.
5. Are single conductor cables allowed to be installed in cable trays? _____ Code Reference _____.
6. If the answer to question #5, is yes, Give the minimum size conductor Permitted. _____.
7. Trays shall be _____ and _____ connected to the enclosure in which cables terminate.
8. Nonmetallic extensions shall be made from a _____ or _____ ampere branch circuit.
9. Nonmetallic extensions may be installed in a residence or _____.
10. An extension shall be attached only to woodwork or _____.
11. Each run of nonmetallic extensions shall terminate in a fitting which covers the _____ of the assembly.
12. Fastenings shall be located a _____ of eight inches on centers.
13. Receptacle type tap connector shall be of the _____ type.
14. An underplaster extension may be used only for extending an existing _____ circuit.

NAME _____

TEST D-1

15. An underplaster extension may be installed in a _____ -
_____ constructed building only.
16. NM cable may be used for underplaster extension. True/False
_____ Code Reference _____
17. Underplaster extensions shall not extend beyond the _____ it
originates unless it is installed in _____ metal _____,
_____ metal clad cable, or _____ cable.
18. Underplaster extensions shall be mounted on the face of _____
walls.
19. The conductors, including splices and taps, shall not fill the
raceway to more than _____ percent of its area at that point.
20. All splices and taps shall be made by _____ methods.
21. The maximum voltage normally permitted in a surface metal raceway
is _____ volts.
22. No conductor _____ than that for which the raceway is designed
shall be installed in surface metal raceway.
23. Surface metal raceways may extend through _____ and _____.
24. Raceways shall be _____ from outlet to outlet.
25. Combination raceways shall have _____ compartments for
signal, lighting, and power circuits.
26. Metal multioutlet assembly may be extended through _____
partitions.
27. Assembly may be installed in _____ location(s).
(a) dry (b) wet (c) both
28. Assembly is a raceway designed to hold _____ and
_____.
29. Assembly may be _____ or _____ assembled.
30. Receptacles in a multioutlet assembly shall be _____-wire,
_____ type.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-6 THRU D-10
TEST D-2

1. Dead ends of raceways shall be _____.
(a) closed (b) left open for future use.
2. The combined cross-sectional area of all conductors shall not exceed _____ percent of the interior area of the raceway except that when raceway contains only type AC or NM sheathed cable.
(a) 40 (b) 50 (c) 60
3. Junction boxes used with metal raceways shall be _____.
(a) metal (b) plastic (c) wood
4. Splices and taps shall be made only in _____.
5. Conductors supplying a discontinued outlet shall be removed from the _____.
6. Underfloor raceways in office buildings may be used for low voltage _____, _____ and _____ systems.
7. The maximum voltage permitted in a raceway is _____ volts.
8. Wires for _____ or _____ systems shall not be run in the same duct with convenience outlet wires.
9. No conductor larger than # _____ shall be installed in any cell or header except by special permission.
10. Inserts shall be _____ continuous with the raceway.
11. Splices and taps shall be made only in header access units or _____.
12. Conductors feeding a discontinued outlet shall be _____ from the raceway.
13. So called loop wiring is not considered to be a splice or tap in cellular metal floor raceway. True/False _____ Code Reference _____
14. Headers permit the installation of electrical _____ from a distribution center to the cells.
15. Core _____ are used to cut hole in center of cell.

NAME _____

TEST D-2

16. In general, the cells of a cellular metal floor are on _____ inch centers.
17. No conductor larger than # _____ shall be installed, except by special permission.
18. Connections to cabinets and extensions from cells to outlets shall be made by means of _____ or _____ conduit or approved fittings.
19. Headers is a metal raceway providing access to predetermined _____ in the slab.
20. Header duct shall be _____ continuous through the system and shall be _____ bonded to the enclosure of the _____.
21. Connections between cabinet and header shall be made by means of _____ and _____.
22. A _____ conductor shall connect the receptacle to a positive ground connection on the _____ duct.
23. Busway shall be installed only for _____ work.
24. Busways may be installed as service _____ conductors.
25. Busways may extend through floors provided a totally _____ busway is installed up to a minimum of _____ feet above the floor for physical _____.
26. Branch circuits from busways shall be provided with _____ - in devices.
27. Busway taps, having a minimum rating of _____ the ampere capacity of main duct protective devices and a maximum length of _____ feet, are not required to have _____ protective devices.
28. Rating of the overcurrent _____ device determines the ampere rating of the busway branch circuit.
29. Plug-in bus duct overcurrent protective devices are either:
 - (a) _____
 - (b) _____

NAME _____

TEST D-2

30. One-volt construction of modern bus duct systems require _____ wrenches to assure proper joint connection.
31. Busways are normally hung by what three methods?
- (a) _____
 - (b) _____
 - (c) _____
32. Cablebus is an approved assembly of _____ conductors mounted in _____ relationship in a ventilated _____ protective _____ structure.
33. The minimum wire size for cablebus conductors is _____ AWG.
34. The conductor insulation for cablebus conductors is _____ °C. The code designation for the insulation is _____.
35. The ampacity of the cablebus conductor is based on single conductors in _____, as found in tables _____ and _____ of the N. E. Code.
36. Cablebus voltage ratings are from zero volts to _____ volts.
37. The supporting structure of cablebus can be used on an equipment _____ conductor when adequately bonded.
38. Special fittings are required for the cablebus system:
- (a) _____
 - (b) _____
 - (c) _____

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-11 THRU D-14
TEST D-3

1. Switches shall not disconnect the _____ of a circuit.
2. Switches shall be mounted in _____ and shall be _____ operated.
3. Single-throw knife switch shall be connected so that blades are _____ or _____ when the switch is open.
4. Voltage between ganged snap switches cannot exceed _____ volts unless permanently installed _____ are installed between adjacent switches.
5. Circuit breakers or switches of special design shall be installed to _____ circuits greater than 1200 amperes at 250 volts or less.
6. Isolating switches are installed to _____ the circuit from the _____ and are intended to be operated only after the circuit has been _____.
7. What two items of information appear on all switches?
 - (a) _____
 - (b) _____
8. _____ shall be accessible only from the front.
9. Switchboards are generally accessible from the _____ and _____.
10. There shall be a _____ foot minimum clearance above a switchboard in a room having a non-fireproof ceiling.
11. Define a lighting panelboard: _____

12. There shall be a maximum of _____ overcurrent devices in a lighting panelboard.
13. Maximum overcurrent protection of a lighting panelboard shall be _____ amperes.

NAME _____

TEST D-3

14. The total continuous load on an overcurrent protective device in a panelboard shall not exceed _____ percent of its rating.
15. An equipment grounding terminal bar is required for all panelboards. True/False _____ Code Reference _____
16. The neutral bar can be used as a terminal for equipment grounding conductors. True/False _____ Code Reference _____
17. Where are the equipment grounding and neutral terminal bars bonded together? _____
18. High voltage equipment and conductors must have _____ sufficient for the voltage employed.
19. Where bare connections and buses are used, insulation is provided by _____. The higher the voltage, the greater the _____.
20. What are the five main methods of installing above ground high voltage conductors?
- (a) _____
- (b) _____
- (c) _____
- (d) _____
- (e) _____
21. What is the purpose of shielding a high voltage conductor?
- _____
22. Is a special type terminator required for metal-sheathed high voltage cable? Yes/No. _____. If so, what type? _____
23. What is the major difference in the equipment installed in regular work and that of high voltage equipment? _____
24. What types of public buildings are covered under Article 520?
- (a) _____ (f) _____
- (b) _____ (g) _____
- (c) _____ (h) _____
- (d) _____ (i) _____
- (e) _____ (j) _____

25. Stage switchboards shall contain _____ protection and _____ for all stage receptacles.
26. Maximum overcurrent protection for a dimmer shall be _____ percent of the dimmer rating.
27. The circuit supply _____ type dimmers shall not exceed 150 volts between conductors.
28. Minimum rating for arc lamp receptacles shall be _____ amperes; minimum wire size shall be # _____ AWG.
29. Minimum rating for _____ lamp receptacles shall be 20 amperes; minimum wire size shall be # _____ AWG.
30. Plugs for _____ and _____ receptacles shall not be interchangeable.
31. Pendant lampholders shall not be installed in _____ rooms.
32. All _____ and _____ in dressing rooms shall be controlled by wall switches.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-15 THRU D-18
TEST D-4

1. What types of communications circuits are covered by Article 800 of the N. E. Code?

(a) _____ (d) _____
(b) _____ (e) _____
(c) _____

2. Circle correct words to make true statements:

These systems (are / are not) connected to a central station and they (do / do not) use similar types of equipment, methods of installation and maintenance.

3. An approved protector shall be installed on each _____ or _____ circuit.

4. _____ communications conductors shall be installed _____ the light and power conductors.

5. Conductors passing over buildings shall be kept a minimum of _____ feet above any roof.

6. Open conductors on buildings shall be separated at least _____ inches from light or power conductors not in _____ or _____.

7. Underground conductors in a manhole shall be installed in a _____ from the light or power conductors.

8. Why should all grounding electrodes be bonded together? _____

Give the N. E. Code Article which allows this. _____

9. Outdoor antenna conductors shall not cross over _____ or _____ conductors.

10. Antenna masts shall be permanently _____.

11. Minimum distance between open conductors of a communication system on buildings and lighting system conductors shall be at least _____ feet.

NAME _____

TEST D-4

12. The grounding conductor shall be of _____.
13. The grounding conductor may be _____ or _____.
14. The grounding conductor shall be connected to a _____
_____ underground electrode by means of a _____
_____.
15. One receiving station grounding conductor may be used for _____
and _____ purposes.
16. Interlocks shall be provided on all _____ access doors.
17. Article 645 of the N. E. Code applies to the following items of
data processing systems:
 - (a) _____
 - (b) _____
 - (c) _____
 - (d) _____
 - (e) _____
18. The ampacity of the branch circuit conductors supplying data
processing equipment shall be at least _____ percent of the total
_____.
19. What are three methods of connecting data processing systems to their
power supply?
 - (a) _____
 - (b) _____
 - (c) _____
20. Branch circuit supply conductors installed under a raised floor
feeding receptacle shall be installed in:
 - (a) _____
 - (b) _____
 - (c) _____
 - (d) _____
 - (e) _____
21. What two systems must be provided with a disconnecting means readily
accessible within the data processing room?
 - (a) _____
 - (b) _____

NAME _____

TEST D-4

22. List the three items of information which must be shown on each item of electrical data processing equipment.

(a) _____
(b) _____
(c) _____

23. Low energy circuits have the _____ limited and are considered Class _____ remote-control circuits.

24. Low voltage power circuits have the _____ limited and are considered Class _____ remote-control circuits.

25. Safety control circuits are considered as Class _____ remote-control circuits.

26. Conductor sizes are usually No. _____ or No. _____ AWG.

27. Match the proper voltage with the limiting current for Class II systems.

Column A Voltage

Column B Low Current

_____ (a) Maximum 15 volts
_____ (b) 15 to 30 volts
_____ (c) 30 to 60 volts
_____ (d) 60 to 150 volts
_____ (e) Maximum 150 volts

1. One ampere
2. 5 amperes
3. 1.6 amperes
4. 5 milliamperes
5. 3.2 amperes
6. 15 amperes

28. Maximum line side protection for a Class II remote-control system transformer is _____ amperes.

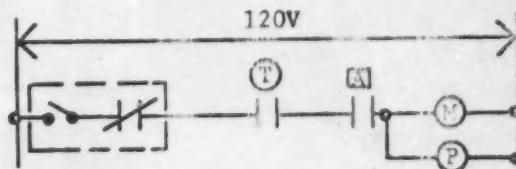
29. Outside installation of Class II remote-control system wiring requires lightning protection. Yes/No _____. Give the N. E. Code section for your answer _____.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-19 THRU D-21
TEST D-5

1. A motor circuit should be converted to a _____ in order to analyze it.
2. In an analysis of a control circuit, always consider the circuit _____ at a time.
3. A repairman should always consider every component of a circuit in its _____ and _____ positions.
4. Be systematic in the study of a circuit contact by _____ and coil by _____.
5. Always study a control circuit through its normal sequence from _____ to _____.
6. A good troubleshooter has the ability to _____ the control circuit and determine quickly which _____ is causing the malfunction of the equipment.
7. Describe the operation of the following schematic diagram:



8. Maintenance means to _____ the equipment in _____.
9. Maintenance is to clean it, _____ it, _____, and _____ it frequently.
10. Improper _____ adjustment is a frequent cause of coil burn-out on brake solenoids.
11. The greatest causes of control system failures are _____ and _____; _____ and _____.
12. Short circuits and grounds may be prevented by the proper inspection of insulation and by using a _____ tester.
13. The first law of maintenance is to _____.

NAME _____

TEST D-5

14. The second law of maintenance is to be a good _____.
15. Motor starter failure is due frequently to _____.
16. Excessive arcing and pitting is caused by improper _____ or lack of contact _____.
17. List two major causes of automatic equipment failure:
(a) _____
(b) _____
18. List two major causes of coil burnout:
(a) _____
(b) _____
19. Time delay relays should be _____ periodically.
20. Limit switches are prone to _____.
21. Troubleshooting of control circuits requires an analytical mind trained in all the aspects of control _____, _____, _____, and circuit _____.
22. Efficient troubleshooting is accomplished by _____ and _____ circuit analysis.
23. The initial step in troubleshooting is to _____ the _____.
24. The second step is to follow the operation of the _____ through the expected _____ to find the _____ of the circuit that is malfunctioning.
25. Control circuits are made up basically of _____ and _____.
26. A basic rule in troubleshooting is to _____ only one thing at a time.
27. A troubleshooter should be equipped with the following testing meters: _____, _____, and an _____.
28. The repairman should change only the _____ that is causing the circuit to malfunction.

NAME _____

DATE _____

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
FOURTH YEAR - SERIES D
LESSON D-22 THRU D-27
TEST D-6

1. A system of machine control which utilizes no _____ parts or _____ contacts is defined as static control.
2. The life of a control system is increased by the use of _____ devices.
3. List five elements of logic functions:
 - (a) _____
 - (b) _____
 - (c) _____
 - (d) _____
 - (e) _____
4. The subject of "static control" can be broken down into three parts:
 - (a) _____
 - (b) _____
 - (c) _____
5. The oldest method of static control uses _____.
6. The most reliable static control uses _____ amplifiers in conjunction with rectifiers, _____ and _____.
7. The "Information Section" of a machine is called _____.
8. The "Action Section" operates an _____ to produce the desired results.
9. Logic devices may have one or more _____ and a single _____.
10. What are the three sections of a transistor?
 - (a) _____
 - (b) _____
 - (c) _____
11. Draw a symbol of: (a) PNP (b) NPN

NAME _____

TEST D-6

12. The middle letter of the transistor indicates the _____ polarity.
13. What are three advantages of the transistor over the vacuum tube?
- (a) _____
- (b) _____
- (c) _____
14. Will a semiconductor diode permit current to flow when it is (a) forward-biased or (b) reversed-biased? _____
15. How would you identify the anode of an unmarked diode? _____
- _____
- _____
- _____
- _____
- _____
- _____
- _____
16. What is a logic circuit? _____
- _____
17. Draw symbols for the following components:
- (a) Resistor
- (b) Battery
- (c) N O Relay Contact
- (d) Capacitor
- (e) Potentiometer

NAME _____

TEST D-6

18. Three basic parts of an electron tube are:

- (a) _____
- (b) _____
- (c) _____

19. List seven principal functions performed by electron tubes:

- | | |
|-----------|-----------|
| (a) _____ | (e) _____ |
| (b) _____ | (f) _____ |
| (c) _____ | (g) _____ |
| (d) _____ | |

20. How does a positive limiter differ from a negative limiter?

21. Why must a device using a power transformer never be plugged into direct current? _____

22. Describe the nature of the output voltage of (a) half-wave rectifier: _____

_____ (b) full-wave rectifier

23. Is it possible for a tube or CRT to check "good" on a tester and yet be inoperative in a circuit? _____ Explain. _____

24. _____ welding and _____ welding are the two general types of electric welding.

25. In _____ welding, an _____ is drawn between the metal parts to be joined together and a metal electrode, and metal from the electrode is deposited on the joint.

26. In _____ welding, the metal parts to be joined are passed tightly together between two electrodes, and a _____ is passed through the electrodes and the metal parts to be welded.

NAME _____

TEST D-6

27. The maximum overcurrent protection for an electric arc welder is _____ percent of the rated _____ current.
28. The minimum capacity of a supply conductor to a varying operation type manual-operated resistance welder shall be _____ percent of the rated _____ current, _____ percent for automatic resistance welders.
29. Maximum overcurrent protection for supply conductors to an arc welder shall be _____ percent of _____ rating.
30. The maximum overcurrent protection for a resistance welder shall be _____ percent of the rated _____ current.
31. The maximum overcurrent protection for supply conductors to a resistance welder shall be _____ percent of _____ rating.
32. Give five reasons why silicon rectifiers are replacing other types of power conversion apparatus:
- | | |
|-----------|-----------|
| (a) _____ | (d) _____ |
| (b) _____ | (e) _____ |
| (c) _____ | |
33. Name three other methods of power conversion apparatus:
- | |
|-----------|
| (a) _____ |
| (b) _____ |
| (c) _____ |
34. What is the most important item you will ever have to manage?
- _____
- _____
35. How is the best way to manage? _____
36. Why must every job have some type of management?
- | |
|-----------|
| (a) _____ |
| (b) _____ |
| (c) _____ |
37. When does job management start? _____
- _____
- _____

NAME _____

TEST D-6

38. List the 5 most important characteristics that make a good foreman.

- (a) _____
- (b) _____
- (c) _____
- (d) _____
- (e) _____